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QUALITY AS A DETERMINANT OF VEGETABLE PRICES

QUALITY AS A DETERMINANT OF VEGETABLE PRICES

A Statistical Study of Quality Factors Influencing Vegetable
Prices in the Boston Wholesale Market

BY

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The charts used in this study are published with the permission of the United States Bureau of Agricultural Economics.

PREFACE

IN preparing the manuscript of this study the writer has attempted to discuss separately, and in different parts of the paper, first, the results of the study and their application to practical problems, and, second, the methods involved and the accuracy and reliability of the results. It is the writer's opinion that such a treatment makes the subject much clearer to the man who is unacquainted with the technical methods involved, and, at the same time gives a statement of the facts which is adequate from the scientific point of view. A statistician who reads this paper may feel at times that the discussion of results in the text should be more detailed with respect to technical methods. If so, it is suggested that he read Part XI on page 109 and the Appendix on page 127, in which sections he will find in a few pages a statement on questions of technique. By this segregation of the general results and the technical aspects of the study, it is hoped that both sections have been made more understandable.

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CHAPTER I

INTRODUCTION AND SUMMARY OF RESULTS

OBJECT OF THE STUDY

THIS study was originally undertaken with a single, definite and extremely practical object. That object was to discover the quality factors—such as size, shape, color, condition, pack and other physical characteristics—which influence the prices of locally grown vegetables in the Boston wholesale market, and, further, to measure quantitatively the influence of these factors on price.

The analysis of prices which forms the basis of the present study is distinctly different in its viewpoint and purpose from that of most statistical studies made to date, and is concerned with a field of price analysis which is comparatively new. For that reason, the marketing specialist and the economist should be interested in the broader applications of this study, its relation to economic theories of value, and its method as a possible approach to the measurement of market demand. Therefore, in its present form the study has two main objects; first, the immediate object which is the measurement of quality factors influencing the prices of certain vegetables in Boston; and, second, the broader object, which is the development of a statistical method of analyzing market demand for quality and the study of the relationship of such price analyses to economic theory.

The market gardener or dealer who is primarily concerned with the practical application of this study to his business will be interested mainly in the summary of results in Parts IV, V and VI, and in the practical application of these facts

as discussed in Parts VII, VIII and IX. Readers who are concerned with the theoretical and technical aspects of the study will be interested mainly in Parts II and III and in Parts X, XI, XII and XIII.

THE INFLUENCE OF QUALITY ON MARKET PRICES

The visitor who sees one of the large city wholesale produce markets for the first time and talks with wholesalers and commission men, is usually impressed by the fact that there is no one standard price for any particular commodity. Especially in the case of some of the more perishable fruits and vegetables, it is common to see certain fancy lots sell at prices from fifty to one hundred per cent above the average market prices while other lots are thrown away as unsalable.

There are many factors which dealers and consumers associate with quality. The variety of the commodity, the section of the country in which it was produced, the brand or trade-mark, the type of package, and the size, shape, color and other physical characteristics of the commodity itself all give buyers and sellers clues concerning the quality of the product. It is the combination of a great number of these factors which finally determines whether a particular lot of apples, lettuce, or any other product will command a premium on the market or will be sold at prices below the average.

Usually a number of expert salesmen and expert buyers agree fairly closely as to the value of any individual box or basket of a commodity. This judgment of buyers and sellers is not, however, usually based on a conscious study of the many quality factors involved, but rather on a general observation of the particular lot of the commodity being offered for sale. While a number of buyers or sellers may agree on the excellence of a certain box of cauliflower, they may be unable to explain fully the reasons for their judg-

ment. If they are asked individually the reasons why this particular box sold at a high price, they are likely to give a variety of answers, most of which are in general terms, such as "large size", "good condition", "well graded", or merely "good quality". A good buyer or seller usually recognizes good quality, but is seldom able to state accurately what the most important elements of quality are and their individual influences on prices. The producer, also, usually knows in a general way whether his crop is of good quality or of poor quality, but is unable to judge the relative importance of the many factors which determine quality.

The measurement of quality, from the standpoint of the producer or the dealer who is financially interested in the product being sold, must be in terms of price. Other measures of quality, such as food value or vitamin content, might represent quality to the nutrition specialist, but as the term is here used, quality factors are those characteristics of the commodities which influence their market prices. These quality factors may or may not reflect food values or health values, but they do reflect the demand of the market. It is impossible in the present study to attempt to answer fully why the market pays more for one quality or grade of a commodity than another. Rather, the study is limited to discovering what the important quality factors are and to measuring the influence of each of these factors on prices.

THE PROBLEM

The commercial market gardener depends for his living on his ability to produce and sell the type of vegetables which the market wants. Agricultural economists have said and written a good deal during recent years about adjusting production to market demand.¹ It has been generally recog-

¹ For a good statement of some of the problems involved in such an adjustment, see Paul L. Miller, "Coordinating Production to Market Requirements," *Proceedings of the National Association of Marketing Officials*, 1926, p. 23.

nized that an intelligent production and marketing program should be based on a careful analysis of market requirements. Such an analysis should determine not only the amount of a given commodity which the market will absorb at reasonable prices, but should also determine the types, varieties and qualities which are demanded.

The producer is not in a position to make such studies of market requirements. Even in Massachusetts where the market gardener is close to the market, he is usually unable to spend enough time watching the sale of the produce from his own and other farms to arrive at very definite conclusions concerning the relative value of the many quality factors.

The producer would like to know what qualities bring the highest market prices, and he would like to know as definitely as possible, in terms of dollars and cents, how great a premium he can expect for products of the best quality. If he knew these facts, and also knew the methods and costs of producing and marketing the various qualities, he would be able to plan his business on a sound basis. Without some estimate of the influence of these quality factors on market prices, the producer cannot intelligently make his plans. Usually the market gardener in making his plans, estimates, to the best of his ability, the prices which he can get for different types or qualities of his products, but without some careful study of the market he is unable to do this accurately. The problem presented here is to supply such market gardeners with more accurate estimates of this kind, based on a careful analysis of actual sales prices of a large number of lots of each commodity which vary considerably in quality.

Another problem which needs some attention is that of discovering an adequate basis for grades. Standard grades have come into general use since the war, due to the concentration of the vegetable industry in specialized sections and

the consequent increase in carlot shipments. The value of grades to the producer, the dealer, or the consumer depends on the accuracy with which they reflect the quality differentials in the market.¹ Such terms as "Fancy", "A Grade" or "Number 1" are meaningless unless it is required that the products using this terminology be of the quality which the market demands and for which it is willing to pay a premium. Without some detailed study of the market, it is impossible to determine what the proper basis for grades should be.

While market preferences have probably received some consideration in the fixing of grades for all agricultural products, this has not usually been the only consideration. In writing the grade requirements, the producers have often been much more adequately represented than either the dealers or the consumers. In such a case, the basis of the grades adopted is likely to be what the producers think they can meet, rather than what the market wants. Where the grades are to be used over a large producing area, the tendency is likely to be to make the requirements low enough so that a large number of producers in all parts of this area can meet the requirements of the "Number 1" grade. Without any question, the grade requirements would be more useful and more satisfactory to all concerned if dealers and consumers could meet with the producers and help draft the grades.

Even with all interested parties represented, it would be advantageous to get as much detailed information as possible about market preferences and to study the relation of the many quality factors to market prices before grade requirements are adopted. Such studies will give a clearer, more definite, and more accurate picture of the market de-

¹ Lloyd S. Tenney, "National Standards for Farm Products," U. S. D. A. *Circular No. 8*, 1927, pp. 2 and 3.

mand for various qualities than can possibly be given by the judgment of a few individual producers, dealers or consumers.

Market reports and their interpretation offer another problem in connection with which this study may be of some value. The market quotation for any commodity represents the reporter's judgment of the prices at which the "bulk of the sales" took place. If the prices quoted refer to specific grades of this commodity, the range is likely to be small; if not, it must be rather large in order to represent a fair proportion of the sales. Thus, the quotation for "A Grade", 2¾-inch McIntosh Apples might be \$2.50 to \$3.00 per bushel, while if the reporter did not quote by grades, it might be necessary to quote a range from \$1.50 to \$3.25. Since most of the locally grown vegetables in Boston and other large markets are not sold according to standard grades, the range in the price quotations is usually large. This reduces the value of the report. Some study of quality is necessary to interpret such reports for farmers and other interested parties. Such studies should, first, test the accuracy of the reported prices, and, second, discover what types and qualities of each commodity usually sell near the top of the quoted range in prices and which sell near the average and near the bottom.

The relation of quality to prices also presents a problem in economic theory. In the actual market one seldom finds only one price for a commodity at the same time and place, because most commodities are not made up of units of exactly equal quality. Any theory, in order adequately to explain prices, must, therefore, take quality into consideration. It must show the importance of quality factors as price determinants, and must offer some conclusions concerning the relation between these factors and prices.

MATERIALS AND SOURCES

The data used in making this study are the result of careful and detailed inspections of a number of lots of asparagus, tomatoes, and hot-house cucumbers combined with the actual sales prices of the same lots as shown by the books of the commission houses which sold them. The inspections were made by three investigators of the Massachusetts Department of Agriculture. Each morning these investigators visited the Boston wholesale market, chose six or eight lots of a commodity which were typical of the quality on the market, took samples of each lot (usually two or three boxes of each lot were taken as a sample), and made a careful, detailed inspection of these samples. The actual sales prices of these same lots were obtained either the same day or the following day from the commission men. The investigators received the cordial cooperation of the commission men in this study, and were allowed to inspect any number of samples and to get a record of prices from the books.

SUMMARY OF RESULTS

1. Quality factors have an important influence on vegetable prices. See pages 39 to 63.
2. The influence of many of these factors can be measured. See pages 111 to 124.
3. Three important quality factors influencing asparagus prices are (1) the amount of green color; (2) the average size of the stalks; and (3) the uniformity of stalks within the bunch. Variations in the amount of green color were found to be responsible for almost three times as much price variation as were variations in the average size of stalks and almost twenty times as much as were variations in the uniformity of stalks within the bunch. See pages 39 to 45.
4. The three most important factors considered in the analysis of tomato prices were condition, growth cracks and

pack. Condition was by far the most important factor. The Boston market demands firmness above all other qualities. See pages 46 to 58.

5. The demand for various qualities of tomatoes is somewhat different on the various days of the week. On Thursdays condition and color are especially important because of the fact that tomatoes are bought for reshipment. The Saturday demand appears to be for smaller sizes than during the rest of the week. See pages 52, 55 and 56.

6. The Boston market prefers long, slender cucumbers. The highest prices are paid for cucumbers over seven inches long with diameters between twenty per cent and twenty-five per cent of the length. See pages 59 to 63.

7. The results of this study, when combined with certain production studies, lead to definite conclusions concerning production and marketing practices which are likely to be profitable. See pages 64 to 68.

8. In order to make the United States grades for asparagus and cucumbers more useful in the Boston market, local asparagus growers should require a minimum length of green color and the minimum length of hot-house cucumbers should be increased to about seven inches. See pages 72 to 75.

9. The market reports of the Massachusetts Department of Agriculture reflected accurately the prices at which the "bulk of sales" were made. There was, however, a great deal of variation in the actual sales prices which could not be accurately reported. See pages 77 to 85.

10. In general, those qualities which command premiums in the market seem to reflect real superiority in taste, food value or similar indications of "real" quality. See pages 87 to 89.

11. There are some indications that as supplies diminish and average prices increase, the price differentials due to quality decrease. See pages 90 to 95.

CHAPTER II

THE INADEQUACY OF PRESENT KNOWLEDGE OF THE INFLUENCE OF QUALITY FACTORS

THE INADEQUACY OF THE DEMAND SURVEY

UNTIL recent years there have been few scientific studies of market demand for various qualities of food products. Since the war, however, a number of "consumer and dealer demand surveys" have been made. Dealers and consumers have been asked questions concerning their preferences for different varieties, types and qualities of food products. The answers to these questions have been summarized, and have given a general picture of market demand. Such a survey was made in 1924 of the demand of Boston consumers and storekeepers for asparagus.¹ A more general survey of wholesalers' demands for a number of fruits and vegetables was made in Providence, Rhode Island, in 1926.²

There is a small, but growing volume of data concerning market demand for farm products. It is not, however, the type of data obtained in this study. The aim of the demand survey is to discover as many as possible of the quality factors which influence the consumer or dealer who buys the product. The aim of the present study is to select a few of the quality factors which are known to influence the con-

¹ R. W. Harwood, "Market Demand for Asparagus," 1924, unpublished material on file at the Massachusetts Department of Agriculture.

² Roger B. Corbett, "Concerning Wholesale Market Preferences for Fruits and Vegetables in Providence, Rhode Island," Rhode Island Agricultural Experiment Station *Bulletin* 206, 1926.

sumer or dealer and to study quantitatively the effect of variations in these quality factors on prices.

For example, Harwood's survey of the asparagus market showed that Boston consumers wanted green asparagus of large size, straight stalks graded to uniform sizes, evenly-cut butts, tight bunches, compact tips, packed in new boxes or crates, and tied with raffia or tape. This is useful information for the asparagus grower to have, but it is not all he needs to know. He might ask, "Which of these factors are most important, and how much do they affect the prices I can get for asparagus?" The grower needs this definite measure of market demand as expressed in dollars and cents in order to plan his operations to the best advantage. He may be interested in trying to produce a large amount of color on his asparagus in order to satisfy the consumer's demand. But he knows, from experience, that this may reduce his yield per acre and may, also, reduce the average size of his stalks. Therefore, he would like to know rather definitely what premium to expect for greener asparagus and how much loss to expect from the smaller stalks.

The present study attempts to answer such questions as these, and to provide a definite statistical measure of the relative importance of each quality factor and its effect on prices. It does not entirely replace the questionnaire as a method of studying market demand. The two methods will be compared later,¹ and it will be shown that each of these methods can add something to present knowledge. The important fact to be noted here is that the field of demand research cannot be entirely and adequately covered by the questionnaire method because, in its usual form, at least, the questionnaire does not provide a quantitative measure of the relative importance of the various factors considered and their influence on prices.

¹ See chap. x on p. 100.

THE LACK OF QUANTITATIVE DATA

There is very little of this definite, quantitative type of data on market demand available. In a few cases more general statistical studies of supply and demand factors influencing prices have included such quality factors as variety and size. Separate studies of the effect of certain factors on the prices of the cobbler and giant varieties of New Jersey potatoes were made by the present writer in 1923.¹ An analysis of watermelon prices by Heddon and Cherniak in 1924 included weight as a factor.² Dr. Working in his potato-price analysis published in 1925 measured the quality of Minnesota potatoes by the relationship between Minneapolis and New York quotations.³

In these studies the quality factors were subordinated to the study of the causes of changes in average price from day to day or from season to season. No attempt was made to make a careful and detailed study of the quality factors.

More recently—in fact since this study was undertaken—two statistical studies have appeared which have had as their sole object the measurement of the quality factors which cause individual sales prices to vary above and below a normal price such as a market quotation. These studies are an analysis of wheat quality and its effect on prices by Kuhrt⁴

¹ Frederick V. Waugh, "Factors Influencing the Price of New Jersey Potatoes in the New York Market," *Circular No. 66*, N. J. Department of Agriculture, July, 1923.

² Walter P. Heddon and N. Cherniak, "Measuring the Melon Market," *Preliminary Report*, U. S. Department of Agriculture and Port of New York Authority Cooperating, Washington, D. C., 1924.

³ Holbrook Working, "Factors Affecting the Price of Minnesota Potatoes," Minnesota Agricultural Experiment Station Technical *Bulletin No. 29*, 1925.

⁴ W. S. Kuhrt, "A Study of Farmer Elevator Operation in the Spring Wheat Area," Part II, U. S. Department of Agriculture, *Preliminary Reports*, Washington, D. C., October, 1926 and October, 1927.

and an analysis of the influence of quality on the retail price of eggs by Benner and Gabriel.¹

Kuhrt's study published in 1927 shows the influence of protein content, dockage and test weight on the prices received for wheat. Benner and Gabriel's study found almost no relation between retail egg prices in Wilmington and the interior quality of the eggs, but some relationship was shown between prices and the weight and cleanliness of the eggs. As far as the writer has been able to discover, these are the only published studies which have been made to measure statistically the effect of a number of quality factors on prices. These two studies used methods of analysis similar to those used in this study.

Price differentials due to single factors such as variety, size and grade have also been studied to some extent by averaging market quotations. However, no market quotations are subdivided enough to permit a detailed study of the influence of a number of quality factors. For example, the farmer would like to know more than the average difference between the prices of Number 1 apples and Number 2 apples. He would like to know the influence of the many quality factors included in the grades themselves, such as color, insect injury, russeting, hail injury and bruises. He cannot get this information from market quotations.

Thus for the great mass of agricultural commodities, there has been little or no systematic research dealing with market demand for quality. What research there has been in this field has been done almost entirely by the survey method, which, in general, has not been able to evaluate the relative importance of the many quality factors. Except for the studies of wheat prices and egg prices, mentioned above, there is practically no data of a quantitative nature on quality factors which influence market prices.

¹ Claude L. Benner and Harry S. Gabriel, "Marketing of Delaware Eggs," Delaware Agricultural Experiment Station *Bulletin No. 150*, 1927.

THE NEGLECT OF QUALITY IN ECONOMIC THEORY

But what of economic theory? Can such studies as the present one add anything to the existing theories of value and price, or does present theory adequately cover the question of quality?

Economists who are careful in their use of words usually begin their discussions of value or price by assuming a certain set of conditions. These conditions usually include the following: first, perfect competition among buyers and sellers; second, complete knowledge on the part of all buyers and sellers as to current conditions of demand and supply; and, third, a commodity, all units of which are of exactly the same quality. Whether or not the assumptions are stated in these words, a careful reading of the value theories of most economists will show that these assumptions have actually been made. Walras,¹ for example, begins his discussion of prices with the following words: "Le blé vaut 24 francs l'hectolitre. Remarquons en outre le caractère mathématique de ce fait. La valeur du blé en argent, ou le prix de blé était hier de 22 ou 23 francs; elle était tout à l'heure de 23 fr. 50 ou 23 fr. 75; elle sera plus tard de 24 fr. 25 ou 24 fr. 50; elle sera demain de 25 ou 26 francs; mais aujourd'hui, et pour l'instant, elle est de 24 francs, ni plus ni moins."

It is apparent from this rather dramatic statement that Walras assumed, without definitely stating it, that all wheat was of exactly the same quality, or else he was speaking of the quotation of prices for one particular grade of wheat which was defined so carefully that all buyers would pay exactly the same price for all wheat which was sold under that grade. But he neglects, as some other economists have

¹ Leon Walras, *Elements d'Economie Politique Pure*, 3^{me} Leçon.

done, to make clear his assumptions before beginning his analysis of prices.¹

Marshall² qualifies his discussion in the following manner: "Suppose, for instance, that tea of a certain quality³ is to be had for 2 s. per pound. A person might be willing to give 10 s. for a single pound once a year rather than go without it altogether; while if he could have any amount of it for nothing, he would perhaps not care to use more than thirty pounds in the year."

In another part of his book⁴ Marshall makes his qualification even clearer in the following words, "Let us then turn to the ordinary dealings of modern life; and take an illustration from the corn market in a country town, and let us assume for the sake of simplicity that all the corn in the market is of the same quality." It is not necessary to discuss at this point whether or not such an assumption of uniform quality really is an example of "the ordinary dealings of modern life". It is sufficient for the present to note that Marshall recognized the existence of different qualities of corn which influenced actual prices, but that he

¹ It is certain that Walras did make such an assumption. Otherwise, it would be foolish for him to say, "Today, and at this instant, the price of wheat is 24 francs, no more and no less." The farmer or the buyer of wheat would see the fallacy of such a statement. Any man who has had the slightest experience in buying or selling goods on the market knows that the actual prices paid or received for a commodity will depend to some degree on the quality of the goods themselves. It is evident, therefore, that Walras was discussing prices of one particular and perfectly uniform grade of wheat, and was proceeding to analyze the causes of changes in the prices of that particular grade from day to day and from hour to hour. The primary theories of value of most economists have been explained by analyses similar to this, although most writers have stated their assumptions more carefully at the beginning of their discussion.

² Alfred Marshall, *Principles of Economics*, bk. iii, chap. iii.

³ Italics mine.

⁴ *Op. cit.*, bk. v, chap. iii.

was temporarily, at least, disregarding such differences in order to discuss a different aspect of prices.

Jevons¹ defines a market in the following words: "A market, then, is theoretically perfect only when all traders have perfect knowledge of the conditions of supply and demand, and the consequent rates of exchange, and in such a market, as we shall see, there can be only one ratio of exchange of one uniform commodity at any moment." Jevons goes on to explain why the prices of such a uniform commodity change from one period to another.

Carver² makes the following qualification to his theory of value: "The first law of the market is that things of the same kind and quality tend to have the same value at the same time and place. . . . If they are unlike, some being more desirable than others, of course, some will have more power in exchange than others."

The quotations which have been given to show the assumptions made concerning quality have been from comparatively recent and from living writers. This is due to the fact that writers today are more careful to phrase their statement in exact terms. It is probably true, however, that even the earliest economists recognized the fact of price differences due to quality. For example, Smith³ clearly recognized the variations in the quality of labor when he wrote: "It is often difficult to ascertain the proportion between two quantities of labour. The time spent in different sorts of work will not always alone determine this proportion. The different degrees of hardship endured, and the ingenuity exercised must likewise be taken into account. There may be more labour in one hour's hard work than in two hours' easy business; or in an hour's application to a trade which

¹ W. Stanley Jevons, *The Theory of Political Economy*, chap. iv.

² Thomas Nixon Carver, *Principles of Political Economy*, chap. xxii.

³ Adam Smith, *The Wealth of Nations*, bk. i, chap. x.

costs ten years' labor to learn, than in a month's industry in an ordinary and obvious employment. But it is not easy to find any accurate measure, either of hardships or ingenuity. In exchanging, indeed, the different productions of different sorts of labour for one another, some allowance is commonly made for both. It is adjusted, however, not by any accurate measure, but by the higgling and bargaining of the market, according to that rough equality, which, though not exact, is sufficient for carrying on the business of common life."

Smith clearly recognized the fact that the value of labor was not uniform, but that it varied according to quality. But, while he was careful to point this out, he made no real analysis of the reasons for the variation in the value of labor, or wages, according to quality. The statement that these variations in quality are recognized and adjusted well enough for practical purposes does not make the matter any clearer. Some factors are suggested which may have a bearing on the matter such as the intensity of the labor, the length of time necessary to learn the trade, and the skill of the laborer, but we are not told how these factors affect the value of labor. We are told merely that the market takes these things into consideration.

This is practically what later economists have told us about the effect of quality upon prices of commodities in general. In the words of Carver, again, "If they are unlike, some being more desirable than others, of course some will have more power in exchange than others." This is merely the statement of an obvious fact. It is not a theory of value but, rather, a qualification of the main body of the discussion which deals with the causes of price changes from one period to the next for a uniform commodity.

The criticism of economic theories of value presented here is not that they are illogical or incorrect, but that they are not comprehensive enough to explain certain important

aspects of market values. To really understand the economic forces at work in the market determining the prices at which a particular sale of a commodity is made, the student must consider at least two sets of forces; first, the supply-and-demand forces which determine the general level of prices of the commodity; and, second, the quality factors which determine whether the particular sale in question will be made at prices above or below this general level. Such price determination by two sets of forces acting simultaneously and jointly can be visualized only in three dimensions. The usual value theories which analyze the relationship of supply-and-demand factors to prices, and explain changes in the prices of a single quality of a commodity through a period of time, may be considered as expressing a simple, two-dimensional relationship. In a similar way, the present study which analyzes the relationship between quality and prices during a particular period of time expresses a simple, two-dimensional relationship. Neither relationship provides an adequate picture of prices as they exist in the market. A combination of the two analyses might possibly be made and presented in form of a three-dimension diagram, the surface of which would show the prices which would result from any amount of supply and from any quality of the commodity. The "demand curve" which shows the prices which buyers would pay for various amounts of a particular quality of the commodity would be one cross section of this surface. The present study is concerned with curves which show the prices buyers will pay for various qualities at a given time and for a given supply. These curves may be represented as cross sections at right angles to the "demand curve". The present study makes no pretense of setting up a complete theory of prices. It is concerned primarily with one aspect—that of quality as a determinant of prices—and it is suggested that since quality plays an important part in influencing prices in

the actual market that economists should give it more serious attention. This criticism applies equally well to all schools of economic thought. It is not aimed primarily at the classical school, for example, for that school is not more guilty than our contemporaries in its neglect of the quality aspects of prices.. It is not a plea for inductive, rather than deductive, reasoning, for both are necessary to arrive at sound conclusions concerning the relationship of quality to prices. Nor does this criticism imply in any way that the price theories of any schools of economic thought are incorrect, but, rather, that all are incomplete and that a careful, detailed treatment of quality would not only represent better the facts of the market place, but would also provide a price theory which would be more useful since it could be applied to a greater range of problems.

NECESSITY OF RECONSIDERING ASSUMPTIONS WHICH
FORM THE BASIS OF ECONOMIC THEORY

But, it may be argued that it is necessary to discuss one thing at a time and to subordinate certain aspects of prices in order that the main part of the argument may be made clear. Obviously, this is true. The basic factors which influence prices are psychological in character and are necessarily complex. To get a complete picture of all the factors influencing the prices of a commodity, it would be necessary to understand the mental reactions of the individual buyers and sellers. We cannot hope to get very far with such a complicated and detailed problem unless it can be simplified.

In order to arrive at any satisfactory conclusion, the problem itself must first be defined, and the first step is usually to eliminate all possible outside influences in order to study one particular set of factors. Such a process is not limited to economics but is commonly used in all sciences. The agronomist who wishes to study the effect of nitrogen on the

growth of a certain variety of plants, usually is careful, first, to make sure that all the plots of soil are of the same type; that the plants themselves are reasonably uniform at the beginning of the test; that all plants have equal light and moisture; and, in general, that all the plants have the same opportunity of growth except that they are given different quantities of nitrogen. By eliminating all probable outside influences, the agronomist is able to show definitely the effect of the one factor he wishes to study.

However, the agronomist, by making such a study, cannot arrive at a complete theory of plant growth. He is studying one particular aspect of the problem, and many such studies must be made to discover the effect of a number of causal factors before any attempt should be made to arrive at a general theory of plant growth. This is just as true in economics. It is perfectly legitimate for the economist to assume certain conditions concerning the market for a commodity and to then analyze the influence on prices of one particular factor or set of factors. But this is not a complete theory of prices as they exist in the actual market, and it cannot be complete until the economist considers the other factors which, for the moment, he has assumed to be non-existent.

In order to make their price theories more complete many economists, after finishing their main line of argument, have returned for a further consideration of some of their assumptions. This is particularly true of the assumption of free competition. Usually, economists have not been satisfied with a discussion of prices as they work out under a system of perfect competition. It is well enough to start out with such a discussion in order to simplify the subject, but it is apparent that prices are not, in fact, always established by economic forces working out freely and unhindered, but that there often is a greater or lesser degree of monopoly

control. The economist wants naturally to build his theory on actual conditions as they exist in the market place, and, therefore, is usually careful to include somewhere in his analysis a statement of the influence of monopoly on prices and how in the actual market place such control may exert an influence which must be considered in price theory. Ely,¹ for example, after devoting two chapters to value and price in a régime of free competition, adds a chapter on monopoly. While not all economists have devoted a whole chapter to the subject, it is the usual practice of recent economists to include in their price theories some treatment of the subject.

Such a reconsideration of original assumptions brings economic theory into closer harmony with the facts of the market. The economist might be able to construct a logical theory to show how prices would be determined under a régime of socialism; or under a régime of slavery; or under a régime where all industries were controlled absolutely by separate monopolies. He might, logically, make any assumptions he wished, and proceed to show how prices would be determined under such conditions. But economic theory has no value except in so far as it deals with actual conditions and interprets the forces that are at work in the market.

It is, perhaps, self-evident that few, if any, commodities satisfy the assumption of perfect uniformity. There is little variation in the quality of different units of some manufactured products. For example, little variation will be found in the quality of a number of tubes of toothpaste of a particular brand, but, on the other hand, the quality of many important commodities is so variable that some units are valueless while others command high prices. It will be shown later in this study that the quality of certain vegetables sold in Boston is extremely variable, and that this variation in quality is reflected in the prices received in the

¹ Richard T. Ely, *Outlines of Economics*, 1920, chap. xii.

market.¹ If economic theory is to fit the facts of the market, it must explain the causes of this price difference between various lots of the same commodity at the same time and place. And it should be noted here that variations in quality are not limited to farm products. All commodities are subject to some degree of variation in quality and many manufactured articles are far from uniform.

In order to base his theory on the facts of the market, therefore, the economist should re-examine his assumption of uniform quality and include some consideration of the influence of quality on the market, in the same way as he re-examines his assumption of perfect competition and considers the effect of monopoly control. As a matter of fact, writers of economic theory have not done this. None of the schools of economic thought have given serious consideration to the effect of variations in quality on prices in spite of the obvious fact that such variations exist and is often an important factor on the market. It would seem, therefore, that some study of this aspect of prices might give fruitful results.

It may be argued, however, either that the problem has been sufficiently covered by the so-called theory of substitution, or that it is so simple as to require no analysis. Let us examine these two arguments.

THE THEORY OF SUBSTITUTION

Theories of substitution of one consumption good for another have been discussed at some length by economists of the mathematical school. These writers have been concerned with the interdependence of prices. In the words of Marshall,² "For instance, the list of demand prices for tea

¹ The writer was informed that on May 23, 1928, a certain brand of asparagus brought as high as \$12.00 per box in Boston while other unbranded lots sold for \$2.00 per box. This is not unusual.

² Alfred Marshall, *Principles of Economics*, bk. iii, chap. iii, p. 6.

is drawn out on the assumption that the price of coffee is known; but a failure of the coffee harvest would raise the prices throughout the demand schedule for tea. The demand for gas is liable to be reduced by an improvement in electric lighting; and in the same way a fall in the price of a particular kind of tea may cause it to be substituted for an inferior but cheaper variety".

The conclusions reached by writers of this school regarding the mutual interdependence of prices are, first, that if the demand and supply schedules of all buyers and sellers were known for all commodities bought and sold, and if all had perfect knowledge of the supply of each commodity in a market governed by perfect competition, it would be mathematically possible to determine the resulting price of each commodity and the amount sold; and, second, that prices would be so adjusted necessarily that "the marginal utilities of all articles consumed by a given individual are proportional to the marginal utilities of the same series of articles for each other consumer, and this uniform, continuous ratio is the scale of prices of those articles."¹

Perhaps the relationship of these conclusions to the present study are not apparent. Certain differences will be noted in the type of problem discussed by the mathematical school of economists and the type of problem attacked by this study. First, the mathematical school is concerned primarily with the interdependence of prices of different commodities, while the present study is concerned only with prices of various grades and qualities of single commodities. This, however, is a minor distinction, and the conclusions of the mathe-

¹ Irving Fisher, *Mathematical Investigations in the Theory of Value and Prices*, chap. iv, par. 3.

The conclusions of this school of writers will be found in more detail in the following sources: W. Stanley Jevons, *The Theory of Political Economy*, chap. iv; Leon Walras, *Éléments d'Économie Politique* 13^e Leçon.

mathematical school lose none of their validity if applied to the interdependence of prices among various grades or qualities of a single commodity. In fact, it is undoubtedly true that substitution is easier and more commonly practiced among grades and qualities of a single commodity than among different commodities. For example, peaches and cantaloupes may be substituted for each other to some extent and this causes prices of the two commodities to move in sympathy with each other. But it is certainly true that different varieties, sizes, grades and qualities of peaches may be substituted for each other, and that the prices of these different kinds of peaches are, therefore, interdependent.

There is, however, an important distinction between the problems attacked by the theory of substitution and the problem attacked by the present study. The theory of substitution is concerned with the interrelationship of prices of different goods or different types of the same good *after the facts are known concerning the demand for each good or for each type of good*, while the present study is primarily interested in discovering the facts concerning the demand for the various types of individual commodities. This difference in objectives perhaps can be shown clearly by an example. The present study is concerned with discovering certain facts about the demand for various lengths and shapes of hot-house cucumbers. If next year the average length of cucumbers on the market should increase without a change in demand, the relationships between prices of cucumbers of various lengths probably would be changed. The theory of substitution would be concerned with explaining this change in relationships. The theory of substitution helps to interpret the results of the present study, but does not cover the same field.

IS ANY CONSIDERATION OF QUALITY NECESSARY
IN ECONOMIC THEORY?

Perhaps some economists might contend that no careful consideration of the subject is necessary. While it is certain that quality has an important influence on market prices, it may appear that its influence is so obvious that it needs no special attention. We all know that prices will vary directly with quality. Perhaps that is sufficient. The only answer to this argument which can be presented here is that further study of the question may show that the relationship of quality to prices is not so simple and obvious as it appears at first. To the average man on the street, the relationship of prices to supply and demand appears simple. To the economist who spends his life in studying it, the problem is complex. It might be well, therefore, to study quality and its influence on prices in some detail before making a final judgment.

The following analysis of vegetable prices does not attempt to set up a theory of prices, but it may suggest some considerations for future study.

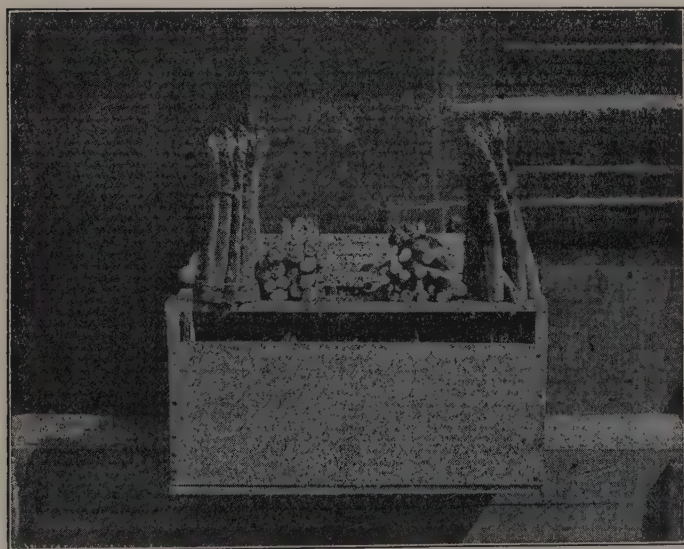
CHAPTER III

ANALYSIS OF ASPARAGUS PRICES

QUALITY FACTORS AN IMPORTANT INFLUENCE ON ASPARAGUS PRICES

ON any given day there is considerable variation in the prices obtained for different lots of asparagus in Boston. Figure 1 shows two lots of asparagus which were sold in

FIGURE 1



the same commission house on the same morning. One lot brought \$1.50 per dozen bunches and the other brought \$4.00 per dozen bunches. This difference in prices was due to dif-

ference in quality. The asparagus on the left-hand side is extra fancy. It is green from the tips to the butts. The stalks are large, straight and of uniform size. The bunches are compact. It is easy for the dealer to obtain good prices for this type of asparagus. Hotel-keepers and buyers for restaurants often leave standing orders for certain brands of asparagus which meet such high-quality standards. The asparagus on the right-hand side is classed as "junk". It is white. The stalks are small, crooked and uneven in size. The butts are jagged and uneven. The asparagus looks old and tough and fit for nothing but soup.

It is easy to compare a lot of extra fancy asparagus with a lot of extra poor asparagus and show the good points of the one and the bad points of the other. A trained market specialist might be able to make a fairly complete list of desirable and undesirable qualities of asparagus for the Boston market. But the large number of factors complicates the situation and makes it impossible without some detailed statistical study to measure the relative importance of the various factors and their net effects on prices. This is the object of the present study.

SOURCES OF DATA AND METHODS OF ANALYSIS

The following analysis of asparagus prices is based on records of inspection of two hundred lots of asparagus in the Boston Wholesale Market, together with a record of the actual prices received by the dealer for each lot. These records were made by Mr. Kroeck of the Massachusetts Department of Agriculture, and cover the entire local marketing season from May 6 to July 2, 1927. A sample record is shown on page 150. A preliminary study of two hundred records of this kind indicated that the most important measurable quality factors were (1) the length of green color, (2) the average size of the stalks, and (3) the uni-

formity in size of stalks within the bunch. The influence of these factors on prices was, therefore, studied by multiple correlation methods in order to estimate their relative importance and their net influence on prices.

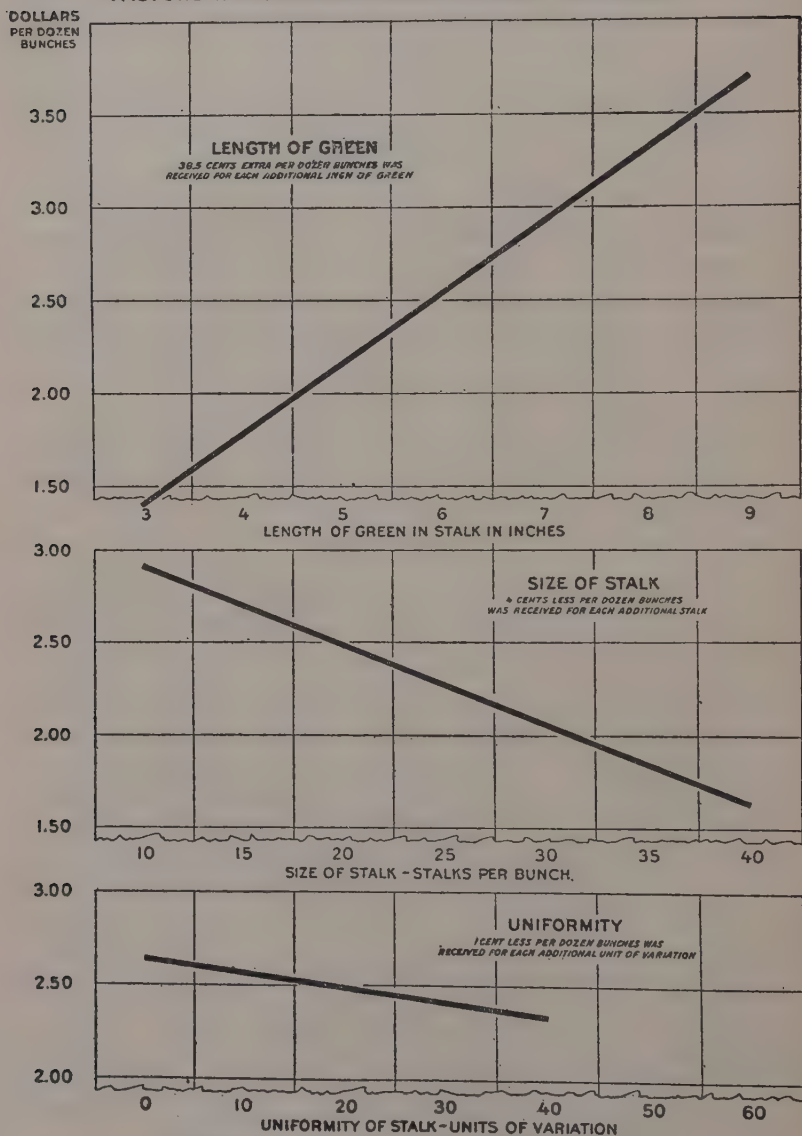
The statistical methods used and a discussion of the accuracy and reliability of the results will be found in Part XI on page 109. A statistical summary of the original data and the results of the study will be found in the appendix. The following discussion of results is made in simple form for the definite purpose of making it understandable to those who are not statistical experts. The statistician will, however, be able to find a more exact statement of the results, and it is hoped that in this way the study loses none of its scientific value and at the same time is clearer, not only to the farmer, but also to the marketing specialist, the economist, and, perhaps, to the statistician, himself.

GREEN COLOR

The length of green color was found to be by far the most important quality factor which influenced asparagus prices in Boston. Figure 2 shows in a popular way the influence of three quality factors. It will be seen that during the period studied the average effect of each additional inch of green color was to increase prices $38\frac{1}{2}$ cents per dozen bunches. In other words, if asparagus of average quality with four inches of green should sell on a particular day for \$1.78 per dozen bunches, asparagus of the same quality but with five inches of green would tend to sell for about \$2.16 per dozen bunches. As the chart shows, there is a big difference between the price paid for a large amount of green color and a small amount. Other things being equal, asparagus with three inches of green was worth \$1.39 in 1927, as compared with the value of \$3.70 for asparagus with nine inches of green.

FIGURE 2

FACTORS INFLUENCING PRICES OF NATIVE ASPARAGUS *



* DATA GATHERED ON 200 BOXES SOLD ON THE BOSTON MARKET, MAY 6 TO JULY 2, 1927

This factor is especially important because there is a large variation in the amount of green color on the asparagus in the market. Certain producing sections and certain individual producers are noted for their ability to produce asparagus with a large amount of green color. Other sections and individuals have the reputation of cutting their asparagus with only three or four inches of green color. The result is that the amount of green color on the asparagus in the market on any particular day is likely to range all the way from three or four inches to about nine and one-half inches. This naturally results in a wide range in prices, since green color is demanded by Boston buyers.

As a result of this demand for green asparagus and the large variation in the amount of green on the asparagus in the market, it was found that over forty per cent of the variation in market prices could be attributed to this one factor. Variation in green color was responsible for almost three times as much variation in prices as was variation in the average size of stalks and almost twenty times as important as variations in the uniformity in the size of stalks within the bunch.

AVERAGE SIZE OF STALKS

The average size of stalks can be measured most easily and accurately by counting the number of stalks in the bunch. Also, this is more easily understood by the packer, because his grades are usually based on a count of the number of stalks per bunch, rather than on a measured diameter. All the records included in this study were made from inspections of bunches of the Massachusetts standard size which weigh from one to one and one-quarter pounds. The packer must make his bunches almost exactly of this size in order to pack them correctly in either the Massachusetts standard box or the asparagus crate. Therefore, a count of

the number of stalks per bunch provides a fairly accurate measure of size.

The more stalks there are in the standard-size bunch, the smaller is the average diameter. It was found that, other things being equal, each additional stalk per bunch tended to decrease prices about $4\frac{1}{2}$ cents per dozen bunches, that is, a dozen bunches containing twenty-five stalks each tended to sell for about 45 cents less than a dozen bunches containing fifteen stalks each when the two lots were of the same quality. While the number of stalks per bunch is less significant than the length of green color in determining asparagus prices, it is an important factor, and accounted for about fifteen per cent of the variation in the prices of the sample studied.

The grower should be interested in producing large stalks, but not at the expense of any considerable amount of green color. This will be discussed more fully in Part VI on page 64.

UNIFORMITY IN SIZE

The inspection records show the diameter of each stalk in each bunch inspected. From these records it is possible to measure fairly accurately the uniformity in size of stalks—or its opposite, the variation in size of stalks—for each bunch inspected. It was discovered that there is a small premium paid for bunches of uniform-sized stalks. Since it does not cost much to grade asparagus according to size, this premium is probably large enough to afford a small profit to the man who sorts rather carefully to size. The amount of variation in prices due to this factor is comparatively small, however—about two per cent of the total.

Uniformity is especially important to buyers of hotels and restaurants, who like to give the same number of stalks in each serving. They do not like to give one customer four

large stalks on a piece of toast, and another customer eight small stalks. For this reason, uniformity in size probably commands a little higher premium on asparagus of high quality which is sold to the hotel and restaurant trade, while it is not so important for the general family trade.

SUMMARY

The amount of green color, the average size of stalks and the uniformity in size within the bunch had an important influence on the prices received for asparagus. These three factors do not, however, account for all the variation in prices which existed in the market. That is, there was not a perfect correlation between these factors and prices. Other factors which probably influenced prices were the compactness and weight of the bunch, the straightness of stalks, the amount of insect and mechanical injury, the freshness of the product, the method of tying the bunches, the general appearance of the pack, and many other factors which would be noted in any survey of the market. It is impossible to include all of these factors in a statistical study of this kind. The study shows, however, a high degree of relationship between these three factors and the actual prices received for asparagus. The three factors studied account for fifty-eight per cent of the variation in market prices.

CHAPTER IV

ANALYSIS OF PRICES OF OUT-DOOR TOMATOES

THE variation in prices received for various lots of tomatoes on the same day is even greater than the variation in asparagus prices. When the records of actual prices received for 370 lots of out-door tomatoes were compared with the market quotations, it was found that the lowest price was 18 per cent of the average quotation, while the highest price was 350 per cent of the average quotation. The wide variation in prices is due largely to the great difference in quality of the tomatoes and the difference in methods of grading and packing.

The following summary of quality factors influencing tomato prices in Boston is based on records of inspection of 370 lots of tomatoes during the season of 1926 and records of the actual prices obtained by the commission man for each lot. The inspector obtained a large amount of detailed, statistical information in each inspection and this has been used to make a multiple correlation analysis of twelve factors which affected prices. This detailed type of analysis was made partly as an experiment to see whether or not the additional time spent in such analysis would give worthwhile results. A discussion of the statistical methods used in this study and the reliability of the measures of quality will be found in Chapter XI. The following is a simple, non-technical, statement of the influence of twelve factors on the prices of out-door tomatoes.

The day of the week. — The prices of most perishable fruits and vegetables vary somewhat with the day of the week. This is due to a combination of factors. Part of the

variation in price is due to a difference in demand on the part of buyers on different week days. Dealers and consumers buy more on certain days of the week than on other days. Part of the price variation is due to variation in the volume shipped to the market on different days of the week. Part of the price variation is due to a difference in the quality of the products themselves. The correlation analysis enables us to eliminate the variation in prices due to quality factors and to estimate the prices received for average-quality tomatoes for each day of the week.

Averaging the actual prices received each day of the week for all the tomatoes inspected gives the following results :

ACTUAL AVERAGE PRICE PER BUSHEL BOX

Monday	\$2.05
Tuesday	2.22
Wednesday	2.24
Thursday	2.20
Friday	1.97
Saturday	1.57

The correlation analysis shows that part of this variation in prices was due to variation in the quality factors, which will be discussed later. For example, the percentage of firm tomatoes was below the average on Monday and Saturday and above the average on the other days of the week. By making an adjustment to allow for the variation in these quality factors, the following estimate was made of the average price per bushel-box of average-quality tomatoes on the different days of the week :

PRICES OF AVERAGE QUALITY TOMATOES

Monday	\$2.16
Tuesday	2.17
Wednesday	2.18
Thursday	2.14
Friday	1.94
Saturday	1.83

It will be noted that tomatoes of the same quality sold at about the same price all through the week, except for a slight fall in prices on Friday and Saturday.

There is also considerable variation in the type of tomatoes demanded on the different days of the week. The demand for color, size, and condition changes from day to day. This will be discussed later.

Place grown.—The 370 lots of tomatoes which were inspected came from forty towns in New England. Some of these towns do not produce many tomatoes and there are not enough records from these less important towns to make a fair estimate of average prices. There are more than ten inspection records of tomatoes from each of ten towns. The prices received for tomatoes per bushel-box from these ten towns were as follows:

AVERAGE PRICE	
Winchester	\$3.10
Somerset	2.34
Belmont	2.25
Burlington	2.15
Brighton	2.15
Arlington	2.06
Scituate	1.99
Woburn	1.89
Newton	1.80
Stow	1.57

It is evident that there was a wide difference in the prices obtained for the samples from these different towns. The price of the samples from Winchester, for example, was almost exactly twice as great as the price of the samples from Stow. The analysis shows, however, that a large part of this difference in prices is explained by differences in the quality of tomatoes included in the samples from the different towns. The prices of the samples from Winchester were increased because of better pack, better color, better

size, less variation, fewer soft tomatoes, more firm tomatoes and less growth cracks than the average. The price of the samples from Stow was decreased because of poorer pack, less color, undesirable sizes, more soft tomatoes, fewer firm tomatoes and more growth cracks than the average. Tomatoes of the same quality brought about the same price regardless of their origin.

After adjusting the prices to allow for the variation in quality, the following estimate was made of the price obtained per bushel-box for tomatoes of average quality from the ten towns :

PRICE OF AVERAGE QUALITY TOMATOES

Winchester	\$2.34
Somerset	2.04
Brighton	1.98
Arlington	1.96
Burlington	1.96
Belmont	1.96
Stow	1.91
Newton	1.85
Woburn	1.78
Scituate	1.68

There is still some variation in prices which has not been explained by the quality factors considered in the analysis. This variation may be due to one or both of two factors. It may be due to quality factors which were not considered because of the difficulty of measuring them, such as taste. It may be due to the reputation of particular towns or particular brands of tomatoes. These two factors are more or less identical. The reputation of a brand is based on quality. The reason one brand sells consistently above the market price is that buyers have found that they can rely on the quality of the goods they are buying. The general appearance of the pack, the taste and smell of the product, and many other qualities will help to build this reputation. These

are quality factors, but they cannot be measured statistically. We cannot measure in dollars and cents the advantage of superior taste in tomatoes because we have been able to discover no way of measuring the variation in taste.¹

Pack. — All the tomatoes considered in this study were packed in the Massachusetts Standard Box. They were packed in three ways: jumble pack, face and fill pack, and layer pack. Jumble pack means put into the box without being placed. Face and fill means facing the top layer evenly. Layer pack means placing each tomato in regular positions and in layers. The average prices obtained for tomatoes packed in these three ways were as follows:

AVERAGE PRICE PER BUSHEL BOX	
Jumble pack	\$1.57
Face and fill	1.76
Layer pack	2.23

Part of this difference in price is due to difference in quality. The best tomatoes are usually layer packed. The poorest are usually jumble packed. The following estimate shows the price of tomatoes of average quality when packed each of the three ways:

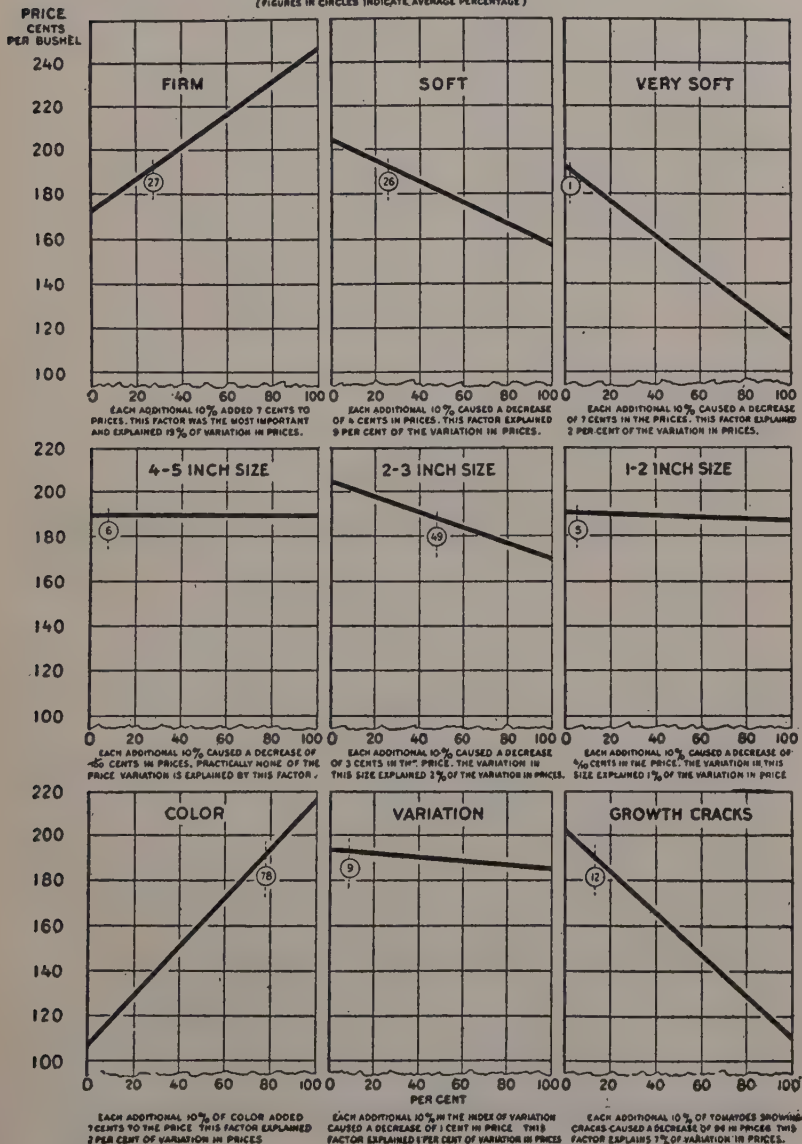
PRICE PER BUSHEL BOX OF TOMATOES OF AVERAGE QUALITY	
Jumble pack	\$1.77
Face and fill	1.86
Layer pack	2.05

¹ Probably there are many quality factors which must be disregarded in a statistical analysis of this kind, at least, until we can find some basis of measurement. But there are certain physical characteristics of many vegetables which can be measured accurately and which are directly related to quality and, therefore, to prices. A study of the relation of these measurable factors and prices gives useful, although incomplete, results. This can be said about almost all statistical studies in the field of economics. There are usually many complex factors at work in the market influencing prices. The statistician measures some of the more important factors, but he is practically never able to consider all the factors which are involved.

FIGURE 3

TOMATOES : EFFECT OF QUALITY FACTORS ON PRICE RECEIVED

(FIGURES IN CIRCLES INDICATE AVERAGE PERCENTAGE)



By facing tomatoes, the producer gained nine cents per bushel. By layer packing them he gained twenty-eight cents per bushel. A producer should be able to determine from this the most profitable method for him to use in packing tomatoes. If it costs less than twenty-eight cents to layer pack, it is likely to pay him to pack by that method, if he has average-quality tomatoes.

The relation of the remaining quality factors to tomato prices is shown in Figure 3. Each factor is discussed below.

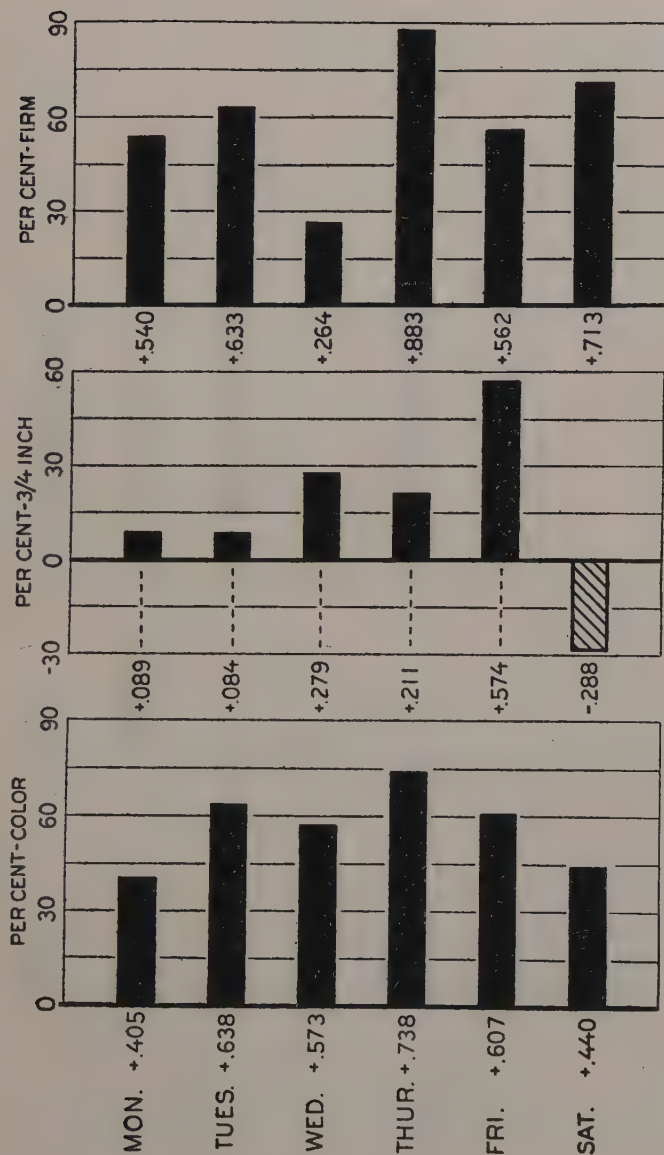
Color.—A record was kept for each lot of tomatoes of the percent of the surface which was covered by a characteristic red color. This percentage ranged from about 40 per cent to 100 per cent. Tomatoes of average color and average quality in other respects sold for \$1.91. Each increase of 10 per cent in the amount of red color resulted in an increase of 3.8 per cent in prices. Tomatoes of average quality which were entirely red sold for \$2.15 as compared with a price of \$1.76 for tomatoes with 40 per cent of the area red. Only about two per cent of the variation in prices was due to variation in the color of the tomatoes. This is largely due to the fact that there was not a great deal of variation in the amount of color in the lots inspected. Color is, nevertheless, important, and the market wants a red tomato.

There was some difference in the demand for color on the different days of the week. Slightly higher premiums were paid for red color during the middle of the week than at the beginning or the end of the week. Figures 4 and 5 indicate the day-to-day variation in the relationships between certain qualities and prices.

The reason for the day-to-day variation in demand for color may be that toward the last of the week buyers are willing to accept poorly-colored tomatoes which will "color up" over the week-end if not sold immediately. Toward the first of the week poorly-colored tomatoes are likely to be

FIGURE 4

TOMATOES: REGRESSION COEFFICIENTS OF
CERTAIN FACTORS FOR EACH WEEK DAY

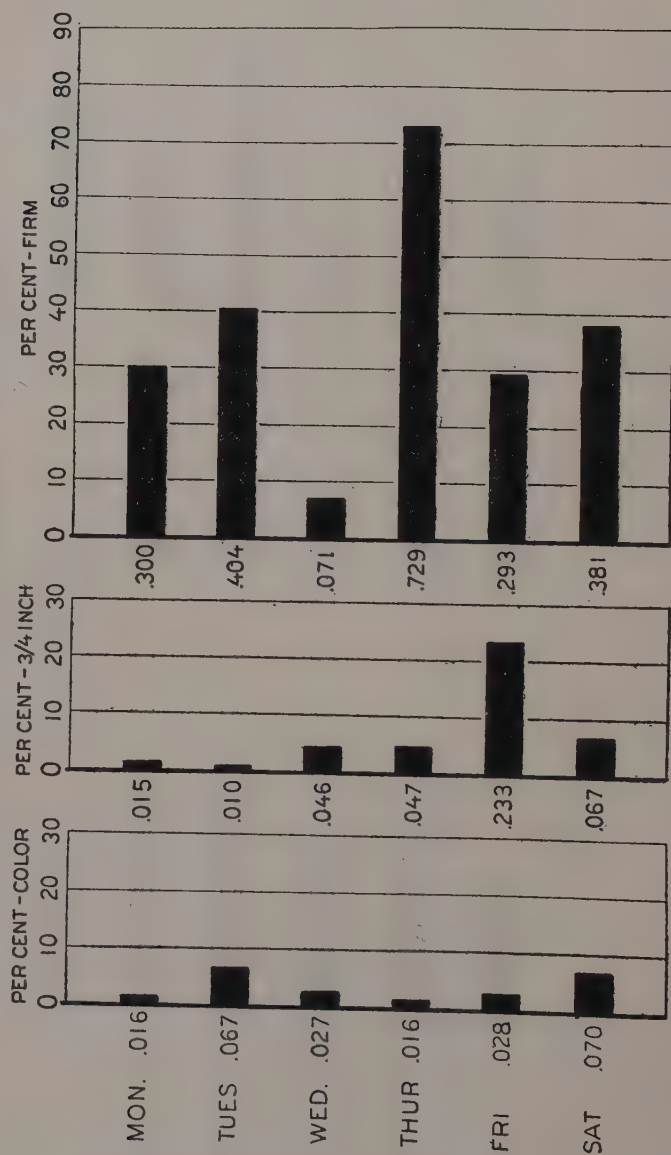


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FIGURE 5

TOMATO PRICES: COEFFICIENTS OF DETERMINATION FOR CERTAIN FACTORS ON VARIOUS WEEK DAYS



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fresh picked while highly-colored tomatoes may have been kept over Sunday. The day-to-day variation in the demand for color, however, was not great enough to be particularly significant. There was on all days a small premium for well-colored tomatoes.

Size.—The most popular sizes for tomatoes in the Boston market are from three to five inches in diameter. Smaller tomatoes sell at slightly lower prices. There is a fair demand for very small tomatoes from one to two inches in diameter, and tomatoes of this size will bring almost as high prices as large tomatoes if the quality is good. The least popular size is from two to three inches in diameter.

The demand for large sizes varies somewhat from day to day during the week. Large sizes are wanted particularly on Fridays and to a less extent on Wednesdays and Thursdays. On Saturdays a study of the samples taken shows that there was a premium for the smaller tomatoes.

The premium for small sizes of tomatoes on Saturday is explained by Mr. Campbell, who made the inspections, by the fact that many small tomatoes are received on Saturday for the week-end trade packed similarly to hot-house tomatoes. Buyers may in some cases think they are hot-house tomatoes, and, even if they do not, the diagonal-wrapped pack which has been used by hot-house growers is associated with high quality.

The size of tomatoes is not so important in the Boston market as some other factors. Condition, for example, is about fifteen times as important as size. The tomato grower can afford to sacrifice a little on size, if necessary, in order to get firm tomatoes.

Variation in size. — Tomatoes are often graded to sizes. In order to check up on this type of grading, an estimate has been made of the effect on prices of variation in sizes within

each lot. The result shows that there is a small premium for tomatoes graded carefully to size, but that this factor was relatively unimportant in the Boston market. This factor may be more important in the case of fancy tomatoes which are layer packed, as uniformity in size will add to the appearance of the pack. Except for this, however, the market does not pay a high premium for uniformity.

Condition.—Condition is the most important quality factor which influences tomato prices in Boston. Above all things the market wants firm tomatoes, and nothing will cause lower returns than to send to the market soft tomatoes. Twelve quality factors were included in the correlation study of tomato prices. Of these twelve factors, three are included under condition, the percent of firm tomatoes, the percent of soft tomatoes, and the percent of very soft tomatoes. These three condition factors were more important in their influence on prices than the other nine combined. An increase of ten per cent in the proportion of tomatoes classed as firm had a tendency to increase prices eight cents per bushel; an increase of ten per cent classed as soft decreased prices five cents per bushel; and an increase of ten per cent classed as very soft decreased prices eight and one-half cents per bushel.¹

Condition is especially important on Thursday when the demand is for a very firm tomato. Thursday is known as “shippers’ day” and many buyers from smaller cities in Massachusetts and the neighboring states are in the market to buy products suitable for reshipment. They are interested to some extent in size, color, pack, and other quality factors, but they are insistent on firmness. A soft tomato is practi-

¹ The relationships expressed here between quality factors and tomato prices are all linear. It is probably true that the exact relationship between such factors as the percentage of firm tomatoes and prices could be expressed better in form of a curve, but it was felt that for the purposes of this study the linear relationship was sufficient.

cally worthless to them. The correlation study shows that as a result of this demand, the one factor of firmness explained 73 per cent of the variation in prices on Thursday, as compared with five per cent explained by size and two per cent by color.

This does not indicate that firmness is not important on other days than Thursdays. It is the most important factor every day in the week. The biggest premiums for firmness are paid on Thursday and Saturday, but buyers always want firm tomatoes and always pay more for them. Tomatoes are very perishable. When eaten at the farm, they may be picked when dead ripe. But tomatoes which are going to the market should not be picked that way. The market does not usually provide ideal storage conditions. After the tomatoes get to the wholesale market, they usually must stand on the street a few hours. They are then trucked to a store. Here they are displayed in a window or on a counter. Often they are picked over by the consumers. The retailer who buys soft tomatoes runs the risk of having to throw out a large percentage of them as unsalable. As a result the buyers have learned to demand first of all that their tomatoes must be firm, and they are unwilling to consider buying tomatoes which are even slightly soft, unless the price is low.

Growth Cracks. — One of the most important defects in tomatoes is growth cracks. Fancy tomatoes should be carefully graded to eliminate any sign of this defect. A study of the records of the 370 lots of tomatoes which were inspected shows that this defect caused more variation in prices than any other factor except condition. Other things being equal, an increase of ten per cent in the amount of tomatoes showing growth cracks tended to decrease prices ten cents per bushel.

Summary.—Because of the detailed type of analysis made in the study of tomato prices it has been necessary to discuss the results at some length. Some of the factors considered were found to be relatively unimportant. A short summary of the results may be helpful.

The most important factors affecting tomato prices are marketing factors rather than production factors.¹ The three most important factors were found to be condition, growth cracks, and pack. Condition is especially important. High premiums are paid for firm tomatoes. Soft tomatoes sell only at low prices. Growth cracks are a serious defect and their presence decreases prices considerably. The method of packing also has a considerable effect on prices. Faced packs averaged nine cents more than jumble packs of the same quality while layer packs averaged twenty-eight cents more than jumble packs.

Size and color also have some effect on prices although the relation is not so marked. The best sizes for the Boston market are from three to five inches in diameter, and the market pays a premium for tomatoes which are completely covered with red color.

The twelve factors studied explained slightly less than fifty per cent of the variation in market prices. While this indicates a fair degree of relationship, it is evident that there were other important factors which have not been taken into consideration.

¹ The application of the results of this study to production and marketing practices is discussed in chap. vi on page 64.

CHAPTER V

ANALYSIS OF PRICES OF NATIVE HOT-HOUSE CUCUMBERS

FIGURE 6 shows two lots of native hot-house cucumbers which sold on the same day in the Boston market. One lot sold for \$7.00 per bushel-box and the other sold for \$1.00

FIGURE 6



per bushel-box. What are the quality factors which cause this wide range in prices? In the case of these two lots of cucumbers, it is easy to see some of the good points of one lot and some of the bad points of the other. It is not so easy to measure all these factors statistically. The inspection

records for cucumbers included only two factors which are measurable statistically. They are length and diameter. While these two factors alone do not entirely explain the variation in cucumber prices, yet they are important.

Size and shape are qualities which are plainly evident to the buyer. Also, there is a relation between the size and shape of cucumbers and the interior quality. Long, slender cucumbers do not have large seeds, the flesh is tender and crisp, and the flavor is delicate. The short, chunky cucumbers are likely to have large seeds, the flesh is tougher, and the flavor is likely to be stronger. Because of this, the buyer can easily judge the quality of cucumbers, and he is willing to pay fancy prices if he can get the right size and shape. The short, chunky type of cucumber can be sold only at considerably lower prices.

The following discussion presents in non-technical form the results of a statistical study of cucumber prices. The reliability and accuracy of the results are discussed on pages 109 to 126.

Length. — The length of the cucumbers included in this study ranged from five and one-half inches to ten inches. The average length was eight inches. The correlation analysis showed that on the average each additional inch in length increased prices about five per cent or about 27 cents per bushel. This premium grows smaller, however, as the cucumbers grow larger. As the length of a cucumber increased beyond a certain point, there was no longer a premium of 27 cents and a ten-inch cucumber is worth about the same as a nine-inch cucumber. As the length decreased below the average of eight inches, there was a large drop in prices. The following estimate shows the average price of cucumbers of different lengths, assuming average quality in other respects.

PRICES OF NATIVE HOT-HOUSE CUCUMBERS 61

<i>Length in inches</i>	<i>Average price per bushel</i>
6	\$4.07
7	5.07
8	5.41
9	5.52
10	5.55

Diameter.—Cucumbers should be slender. The ratio of the diameter to the length should be small. In the samples studied the ratio of the diameter to the length varied from 16 per cent to 40 per cent. The ideal ratio is from 20 to 25 per cent. That is, the highest prices were paid for cucumbers the diameter of which was from 20 per cent to 25 per cent of the length. Cucumbers with a diameter ratio of less than 20 per cent sold at a slight disadvantage compared with this ideal diameter and cucumbers having a larger diameter ratio than 25 per cent sold at a greater discount.

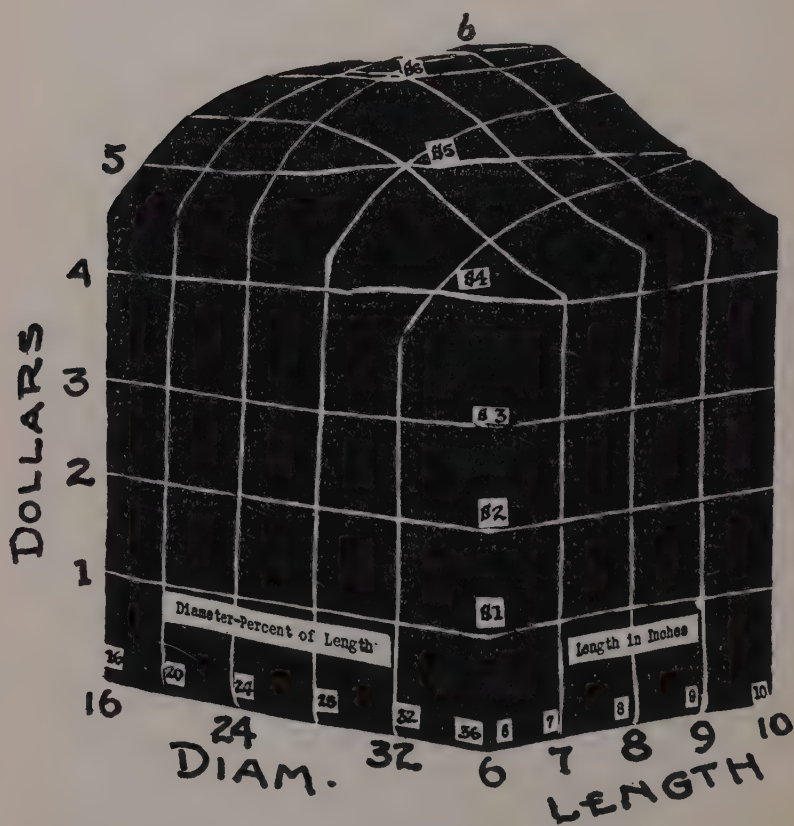
The relation of diameter to prices was as follows :

<i>Diameter ratio</i>	<i>Average price per bushel</i>
15	\$5.16
20	5.51
25	5.52
30	4.71
35	4.11
40	4.07

The relationships between cucumber prices and length and diameter which are discussed above are average net relationships. Actually, the price received for any particular lot of cucumbers will be influenced by both of these factors. It is possible by means of a three-dimension chart, such as Figure 7, to show in one chart the relation of prices to both of these factors. The surface of this solid chart represents the average prices received for cucumbers of various length and diameters. Thus, at the intersection of 36 on the left-hand scale and 6 on the right-hand scale, the surface is just below three dollars on the vertical scale. This means that six-inch

cucumbers with a percentage diameter of 36, (or 2.16 inches), sold at a little less than three dollars. In a similar way it is possible to see from the chart that eight-inch cucumbers with

FIGURE 7



a percentage diameter of 24, (or 1.92 inches), sold for a little more than six dollars, and so forth.

The horizontal lines which measure the dollar values show at a glance the types of cucumbers which brought high and low prices. Thus, the cheap cucumbers which sold from

three to four dollars were less than seven inches long and their diameter was more than thirty per cent of their length. The highest-priced cucumbers, which sold at over six dollars, were over eight inches long and their diameters were from twenty to twenty-five per cent of their length.

SUMMARY

The study shows that the highest prices are obtained for long, slender cucumbers. The ideal size is from eight to ten inches long with a diameter between 20 per cent and 25 per cent of the length. Length and diameter alone explained 59 per cent of the variation found in hot-house cucumber prices. A more detailed study, including such factors as the percentage of misshapen or poorly colored cucumbers, might establish even a higher degree of relationship.

The results of this study have an important bearing on production and marketing policies.¹ It is obviously important to consider varieties and methods of production which will result in the size and shape of cucumbers which the market demands.

¹ See chap. vi on page 64.

CHAPTER VI

APPLICATION OF THE STUDY TO PRODUCTION AND MARKETING POLICIES

THE results of a study of this kind have a definite and practical value to producers. The preceding sections have demonstrated that it is possible to estimate in dollars and cents the market value of certain quality characteristics. Without some such measure, the grower has no basis for deciding on the types and qualities of the commodity which offer the greatest opportunity for profits, nor the methods of grading and packing which should provide him the best return for his efforts.¹

This study has been concerned with measuring the premiums paid for certain quality factors. The producer should, in addition, be able to estimate with some degree of accuracy the relative costs of producing and marketing the various qualities, if he is to use the results of such a study to the best advantage. It might be well here to review the results from the growers' standpoint and to consider their importance.

¹ It should be recognized here that such studies can serve only as a guide to indicate the premiums for quality which were paid during the period studied. If there were a decided shift in production from the lower to the higher qualities these premiums would probably be affected. However, a summary of the influence of quality factors at the present time will be of great deal of value to producers.

THE APPLICATION TO ASPARAGUS PRODUCTION
AND MARKETING

The important quality factors influencing asparagus prices were found to be, first, the amount of green color, which caused forty-one per cent of the variation in market prices, and, second, the size of stalk, which explained fifteen per cent of the price variation. It was found that, on the average, each additional inch of green color was worth $38\frac{1}{2}$ c. per dozen bunches, while each additional stalk in the standard bunch caused a decrease of $4\frac{1}{2}$ c. per bunch. Uniformity in size within the bunch added slightly to prices, but was of less importance.

What practical application have these results to asparagus growing for the Boston market? Obviously, it is necessary, first, to discover whether or not it is possible to grow green asparagus in the sections which ship to the Boston market, and, second, how the cost of producing asparagus with a large amount of green color compares with the cost of growing asparagus with a small amount of green color.

Stalks of all green color can be obtained in any producing section. White asparagus is produced by cutting off the stalks below the ground. As the stalk leaves the ground, it grows green. It is, therefore, easy enough to produce green asparagus. But as the stalk grows green, it often tends to "spindle out", and the tips are often frayed. Therefore, the production of green asparagus is usually attended by some loss in production per acre, by some loss of average size of stalk, and by some decrease in the percentage of the fancy grades. This calls attention to the fact that the analysis of market prices gives the farmer only part of the information he needs in order to arrive at the most advantageous production and marketing policies. He needs to know not only the premium paid for quality products but, also, the relative cost of producing the various qualities on his farm.

The individual farmer may in many cases be able to figure these costs accurately enough for his purposes by observation. A comparison of the premiums paid for green and for size of stalk show that one extra inch of green tends to increase prices $38\frac{1}{2}$ cents per dozen bunches, while it would require about eight extra stalks to the bunch to decrease prices by that amount. The asparagus producer should be able to judge whether or not by producing one more inch of green color he is likely to cut down the size of his stalks so much that eight additional stalks will be required in the bunch.

STUDY OF PRODUCTION METHODS AND COSTS

But it is to the advantage of the asparagus grower to have as definite information on costs as can be obtained. Professor Victor A. Tiedjens, of the Massachusetts Agricultural College Market Garden Field Station, made during the past season a preliminary study of the cost of producing green asparagus in Middlesex County. Experiments were made on the Field Station farm at Waltham and on the farm of a grower in Concord. The fields were divided into two parts. One part was cut with four inches of green color and the other with eight inches of green color. A careful record was kept of the amount, size and grade of asparagus cut from each part of the fields. A preliminary study of these figures indicates that the asparagus growers in the Concord section can advantageously grow from six to eight inches of green in fields of young asparagus in good condition. Neither the yield per acre nor the percentage of fancy asparagus is seriously cut down by such a practice and the prices obtained for the green asparagus are high enough more than to compensate any such loss. In the case of old beds there may be some question as to the length of green which should be cut. The practice of cutting six to eight inches of green in the case of these old beds probably tends to cut down the

size of stalks more than in the case of young beds. There are, however, many asparagus farmers in the Concord section who are cutting four or five inches of green on fairly young beds. These farmers should seriously consider the possibility of producing green asparagus.

The results of this study have already been discussed at two or three meetings in the Concord section and have attracted considerable interest. It is likely that as a result of these meetings and consequent discussions that the Concord section will produce next year a larger percentage of green asparagus.¹

Similar studies of the possibility of producing green asparagus in the Cape section and in the Hadley section would be of considerable value.

THE APPLICATION TO TOMATO PRODUCTION AND MARKETING

The study of tomato prices indicates that the most important quality factors influencing prices are marketing factors. By far the most important factor is condition. High premiums are paid for firm tomatoes. Without any doubt it will pay the producer to harvest, pack and market his tomatoes in such a way that they will be firm when sold. Since growth cracks cause low prices, it will pay the producer to throw out of the good grades any tomatoes which have this defect. The best pack for the grower to use will depend on the quality of his tomatoes and on his estimate of packing costs. If his tomatoes are of average quality he should receive about nine cents per bushel more for a faced pack than a jumble pack, and about twenty-eight cents more for a layer pack than for a jumble pack.

¹ Another asparagus season is now under way as the manuscript of this study is being revised. A number of growers in the Concord section are producing a larger amount of green color than ever before, and there has been some discussion among growers of increasing the requirement for color in the fancy grade.

THE APPLICATION TO THE PRODUCTION AND MARKETING
OF HOT-HOUSE CUCUMBERS

The study of hot-house cucumber prices showed the importance of growing long, slender cucumbers. This involves growing the right varieties and using the best cultural practices. Most of the market gardeners who are producing long cucumbers are growing the Belleville type. In the Dighton section many of the green-house men are growing the Granite State variety, which tends to produce short, chunky cucumbers. This variety has been grown largely because it is not susceptible to the red mite. It is now possible, however, through good cultural methods to control this pest and any section can produce cucumbers of the Belleville type. During the past season a number of growers in the Dighton section have experimented with the long-type cucumbers with considerable success. They were interested in the longer types largely as a result of this study, which showed that the market was paying a premium for the long varieties.

THE PRODUCER'S INTEREST IN MARKET DEMAND

This discussion indicates that the results of this study have been of a practical nature and have already been of some value to New England farmers. It is important that growers of farm products be supplied with as detailed and complete information as possible concerning the types and qualities of these products which are demanded by the market and the amount of premium paid for these types and qualities. It is recognized that this information does not supply all the facts which the farmer needs in order to decide on the types and qualities of products which he will grow. It is necessary, in addition to this material, to get detailed information of the relative costs of producing and marketing these various types and qualities.

CHAPTER VII

APPLICATION OF RESULTS TO GRADING REQUIREMENTS

STANDARD grades which are used to describe the quality of particular lots of a commodity should be based on those factors which influence the dealer or consumer. The requirements for the use of such terms as "Fancy", "Number 1" or "A Grade" should be such that the products which meet these requirements bring the highest prices in the market. Lower grades, such as "Number 2" or "B Grade" should require qualities which will enable the products to sell readily, but which sell at lower prices than the qualities required in the highest grade. If further grades are needed, each lower grade should require qualities which bring lower prices. In other words, the series of grades, (Fancy, Number 1, Number 2, etc.), should reflect differences in quality as expressed by price differentials.

This fact has been recognized, to some extent, at least, in drawing up grade requirements for most commodities. Yet other factors have been considered. Most of the grades for farm products now in use in the United States have been written largely by producers. This is true, not only of grades adopted by individual farmers and by farmers' cooperative marketing associations, but applies rather generally to the grades established by law or by the regulations of the departments of agriculture of the various states and of the United States. This does not mean that dealers and consumers have not been consulted in the matter, nor does it mean that no studies have been made of market requirements

for various qualities, but the final decision as to the qualities to be included in grade requirements has usually been left largely to the producers.

The producer is interested not only in requirements which fit the needs of the market, but also in requirements which will meet the approval of farmers in the different producing regions. This sometimes presents a real difficulty, because, if grades are to be used over a large area, farmers in the poorest regions of that area often feel that the requirements should be low enough to meet their approval.

PRODUCTION CHANGES WITH CHANGES IN DEMAND

Successful manufacturers base their businesses frankly on production of what the public wants to buy. The past year has seen a large automobile plant closed for months and millions of dollars spent in order to bring out a new model. There was no question of which type of automobile the manufacturer preferred to make. The only consideration was that of manufacturing and selling an automobile which the public wanted to buy.

The American farmer, also, is constantly, although slowly, adjusting his production to meet market requirements. The number of McIntosh apple trees in New England has increased rapidly during the last few years as a result of strong market demand and high prices for this variety of apple.¹ The acreage of tobacco in New England decreased about twenty-five per cent in 1926 as a result of an over-supply of certain types of tobacco on the market,² and is now increasing slightly, as the result of better demand. Such changes

¹ *The Apple Situation in New England, 1927*, published by the Agricultural Experiment Stations of Connecticut and Maine and the Agricultural Extension Services of New Hampshire, Massachusetts and Rhode Island.

² *U. S. Department of Agriculture Yearbook, 1926* and Frederick V. Waugh, Connecticut Agricultural Experiment Station *Bulletin No. 134*.

in production are being made every year in an attempt to meet market demand for quality. But, in the making of grades, other considerations have often been taken into account.

THE UNITED STATES GRADES FOR ASPARAGUS,
TOMATOES AND CUCUMBERS

If grades for farm products are to be based frankly on those qualities which cause market-price differences, studies such as the present one can be of a great deal of value in pointing out the qualities which should be required. The value of the grades now used by growers of asparagus, tomatoes and hot-house cucumbers who ship to the Boston market can be judged by comparing the grade requirements with the quality factors found in this study to be of greatest importance. Since the grades of the United States Department of Agriculture have been used by producers of these commodities more generally than any other, these grades will be outlined here, and it will be seen whether or not the present study offers any suggestions for changes or additions to the requirements for these grades. It should be remembered that any such suggestions apply only to the Boston market. The demand in other markets may be such that conclusions made on the basis of this study will not apply to the United States grades which are used in all markets in the country. Nevertheless, a comparison of the United States grade requirements with the results of this study should show whether or not the grades are suitable for the use of local market gardeners who ship to the Boston market.

THE UNITED STATES GRADES FOR ASPARAGUS (1927)

U. S. No. 1 shall consist of fresh, well trimmed stalks of asparagus which are not badly crooked; which do not have broken or spreading tips, and which are free from decay and

from damage caused by dirt, disease, insects or mechanical or other means. Unless otherwise specified the diameter of each stalk shall not be less than $\frac{1}{4}$ of an inch and the length shall be not less than $8\frac{1}{2}$ inches. . . . Size—The following terms are provided for describing the diameters of any lot. Very small means less than $\frac{1}{4}$ inches; small means $\frac{1}{4}$ to $\frac{9}{16}$ inches; medium means $\frac{9}{16}$ to $\frac{3}{4}$ inches, inclusive; large means over $\frac{3}{4}$ inches. Color—In addition to the statement of grade and size, any lot of asparagus may be classified as green asparagus if 90 per cent, by count, of the stalks in any lot are of a green color covering not less than $4\frac{1}{2}$ inches of the length of the stalk.

It has been pointed out that the most important quality factors influencing asparagus prices in Boston were, first, green color; second, size of stalks; and third, uniformity of size. Provision is made in the United States grades for marketing a lot of asparagus as "Green" in addition to the grade statement if the stalks show four and one-half inches of green color. Provision is also made for marketing a lot according to the size of the stalks in addition to the grade statement. Uniformity is not required.

Since uniformity of size was found to be a relatively unimportant factor in the Boston market, the fact that the grades do not require uniformity is not a serious drawback.

While green color is mentioned in the United States grades, it is not included in the requirements of the grade proper, and the only requirement for size in the grade proper is that the diameter of the stalk shall not be less than one-quarter inch. This is very small asparagus. It is, therefore, allowable to mark a box of asparagus as "U. S. No. 1", (if it is fresh, well trimmed, straight, with compact tips, and free from decay or damage), even if it has no green color at all, and even if the stalks have a diameter of only one-quarter inch. In the Boston market local producers of asparagus should require a reasonable length of green color, and

a stalk of medium size in the case of their individual or association grades.¹

This does not mean necessarily that some amount of green color should be required for the use of the term "U. S. No. 1", because some markets will take white asparagus at good prices. But New England growers who are interested in the Boston market would do well to add this requirement in deciding on their individual grades or the grades of their associations. Two small cooperative associations of asparagus growers in Massachusetts have been using, for a number of years, grades which are the same as that outlined above except that four and one-half inches of green color are required in order to use either the terms "Fancy" or "A Grade", and the "Fancy" grade requires not more than twelve stalks to the bunch while the "A" grade requires not more than twenty stalks to the bunch. It will be seen that some of the organized asparagus growers have recognized the importance of green color and size of stalks in the Boston market and have added requirements to those stated in the United States grades in order to market a pack of asparagus which will more nearly satisfy the demands of the trade. Recently there has been some discussion among the members of these associations of the advisability of increasing the requirement for green color.

¹ It will be noted that in this study size, length, etc., have been considered as quality factors. The term, quality factors as used here means any physical characteristics of the commodities which influence market prices. In the making of grades, size and "quality" have usually been considered separately, and provision has been made for marking a lot according to both grade and size. This marking may adequately describe any particular lot. However, in case size is shown to be an important factor in determining prices, it is a fair question whether or not some minimum or maximum size should not be included in the requirements for the grade proper. This question is especially important in the case of hot-house cucumbers.

U. S. GRADES FOR FRESH TOMATOES (1925)

U. S. No. 1. shall consist of tomatoes of similar varietal characteristics which are mature but not overripe or soft; well formed, fairly smooth; which are free from damage caused by sun scale, puffiness, catfaces, growth cracks, freezing, disease, insects, hail, scars, or mechanical or other means. . . . Marking requirements for size. The minimum size, numerical count, or description of pack of the tomatoes in any package shall be plainly stencilled or otherwise marked on the package.

This grade covers, in a satisfactory manner, the quality factors which have been demonstrated to be important in the case of tomatoes. It is well adapted, without modification, for the use of New England growers who ship to Boston.

U. S. GRADES FOR SLICING CUCUMBERS (1927)

There is no special United States grade for hot-house cucumbers, and the only official grade in general use is the grade which applies to all cucumbers, whether grown in the hot-house or in the field. This grade is outlined below.

U. S. No. 1—shall consist of cucumbers which may be slightly misshapen, but which are fresh, firm; which are sufficiently mature for slicing purposes but not full grown or ripe, and which are free from decay and from damage caused by dirt, freezing, mosaic or other disease, insects or mechanical or other means. *Unless otherwise specified*, the minimum length of the cucumbers shall be not less than five inches.

This grade requires many quality factors which were not considered in this study, but which are undoubtedly important and necessary. Nevertheless, it is apparent that New England growers of hot-house cucumbers would do well to increase the length requirements, and probably to make some additional requirement concerning diameter. All the hot-house cucumbers included in this study were over five inches

long. Therefore, every lot inspected could have been classed as "U. S. No. 1" if it met the requirement of freshness, firmness, maturity, and freedom from decay and damage. Yet, this study has demonstrated that there was a great deal of variation in the prices received for these lots of cucumbers and that a large part of this price variation could be attributed to differences in the length and diameter of the cucumbers themselves.

INDIVIDUAL MARKET REQUIREMENTS SHOULD BE STUDIED

In making grade requirements for use over the entire country it is, of course, necessary to consider market demand in many cities. These demands may vary considerably. Yet the grade requirements should be such that they will meet the requirements of all markets as satisfactorily as possible. In making grades for a particular region, state, or market some study should be made of the local market demand to see if certain additions should be made to the grade requirements in order to make them more useful to local growers or others who might use the grades.

In outlining such local grade requirements, it is well to use such standard grades as the United States grades as a basis. The fact that they are recognized by the trade all over the country and used by distant growers who ship to the local markets makes it advisable to conform as far as possible to the United States grades. If this is not done, it is certain to lead to confusion. Whatever changes are made should usually be in the form of additions to the requirements of the United States grades. A New England grade for asparagus might well be the same as the United States grade with the additional requirement of a minimum length of four and one-half or five inches of green color. A New England grade for hot-house cucumbers might well be the same as the United States grades with the additional re-

quirement of a minimum length of seven or eight inches and a maximum diameter of two and one-half or three inches.

GENERAL COMMENTS ON GRADES

Studies of this kind on a number of the larger markets in the country might be of considerable value in determining the requirements for the United States grades, or in revising the present grades.

It will probably never be possible to study all the necessary grade requirements by the methods used here. It will be necessary to rely on personal observation of market conditions and the comments of dealers and consumers in judging the importance of many factors. But, while this method is not adapted to the study of all kinds of quality factors, it has the advantage of providing a measure of the relative importance of those factors which are studied, and because of this, it is certain to be useful in determining grade requirements.

CHAPTER VIII

APPLICATION OF THE STUDY TO MARKET REPORTS

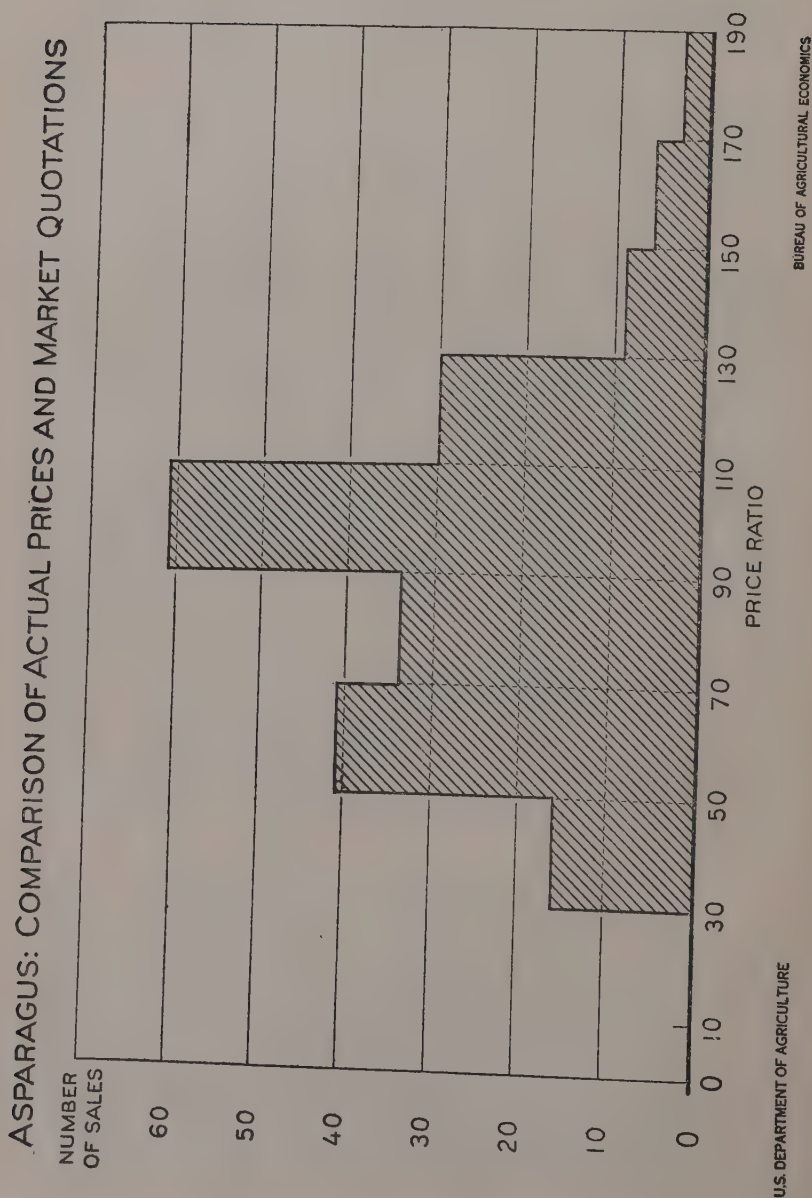
PROBABLY almost every farmer in the United States who produces for the market, uses market reports either occasionally or regularly. Most producers find these reports very useful, and the large producers and cooperative associations who sell in a number of markets find them absolutely necessary for a proper distribution of their products.

Nevertheless, there are some producers who think that quotations are consistently too low and some others who think they are consistently too high. This study makes it possible to compare the actual prices received each day for asparagus, tomatoes and cucumbers with the market quotations for the same day. The lots which were inspected came from many producing sections and the quality varied a great deal. The study should answer two questions: (1) Does the market quotation accurately show the level of prices at which the bulk of the products were sold, and (2) how much variation in prices is there above and below the quotation?

THE ASPARAGUS MARKET QUOTATIONS

Figure 8 shows the relation of asparagus prices to the quotation in Boston Market Report (published by the Massachusetts Department of Agriculture), for No. 1 local asparagus. The actual price received for each lot was compared with this quotation. The chart shows that of the 200 lots which were inspected, 16 lots sold at prices which were between 30 per cent and 50 per cent of the quotation; 41 sold

FIGURE 8



at prices which were between 50 per cent and 70 per cent of the quotation, etc. It will be seen that more asparagus was sold at prices between 90 per cent and 110 per cent of the market quotations than at any other prices. There can be no question that the quotation for asparagus was at about the right level. If it had been 10 per cent higher or 10 per cent lower, for example, it would have represented only about one-half as many sales. The market reporter should report the prices at which most of the products are sold.¹

The producer should notice, however, that there was a large volume of asparagus which sold both above and below the quotation. The study has shown that a large part of this variation in prices was due to variation in quality of the asparagus itself—variations in the length of green, the size of stalks, and the uniformity in sizes. The market reporter does not, and can not, cover all of this price variation in his report. He usually includes a quotation for lower grades and another for the best fancy packs. These quotations allow for a considerable part of the variation in prices. But there is so much difference between extra fancy packs and “junk” such as are shown in Figure 1 on page 39 that the reporter does not attempt to cover them. Usually the producer will find that his quality averages a little better or a little poorer than the bulk of asparagus on the market. His returns will be a little above or a little below the quotation, depending on the quality of his asparagus.

THE TOMATO MARKET QUOTATIONS

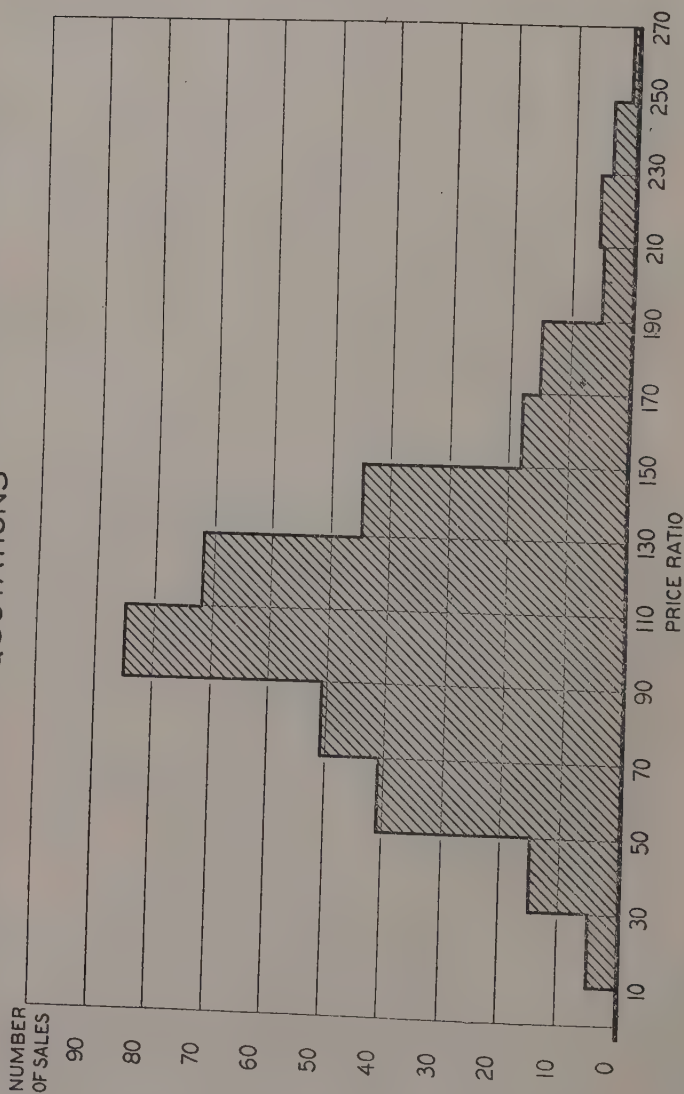
In the case of tomatoes, we find the same condition except that there is more variation in prices.² Figure 9 shows the

¹ The mean percentage price was 90.095 and the standard deviation was 32.6.

² The mean percentage price was 111.24 and the standard deviation was 44.4.

FIGURE 9

TOMATOES - COMPARISON OF ACTUAL PRICES AND MARKET QUOTATIONS



U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF AGRICULTURAL ECONOMICS

relation of the actual prices received for tomatoes and the quotation for No. 1 tomatoes. It will be seen that more tomatoes were sold at prices between 90 per cent and 110 per cent of the market quotation than in any other price group. There was, however, a great deal of variation in the actual prices received for tomatoes of different qualities. The market report gave a fair and accurate record of the price level at which the bulk of the tomatoes were sold. The price quoted is more accurate than it would be if it were 10 per cent higher or lower, but there were many producers who received lower prices and many who received higher prices.

THE CUCUMBER MARKET QUOTATIONS

In the case of cucumbers, the check on market reports is not so conclusive. Figure 10 shows that there was less variation in prices.¹ A large proportion of the sample taken sold at prices between 90 per cent and 130 per cent of the quotation for No. 1 cucumbers. Seventeen lots sold at prices between 90 per cent and 110 per cent of the quotation and twenty lots sold at prices from 110 per cent to 130 per cent of the quotation. It might appear from this that the quotation for No. 1 cucumbers was too low. This would be true if there were only one quotation and if the sample is fairly representative, but the range in prices included in the market quotation covers almost all the group of cucumbers which sold at the higher prices. The quotation usually reads somewhat as follows:

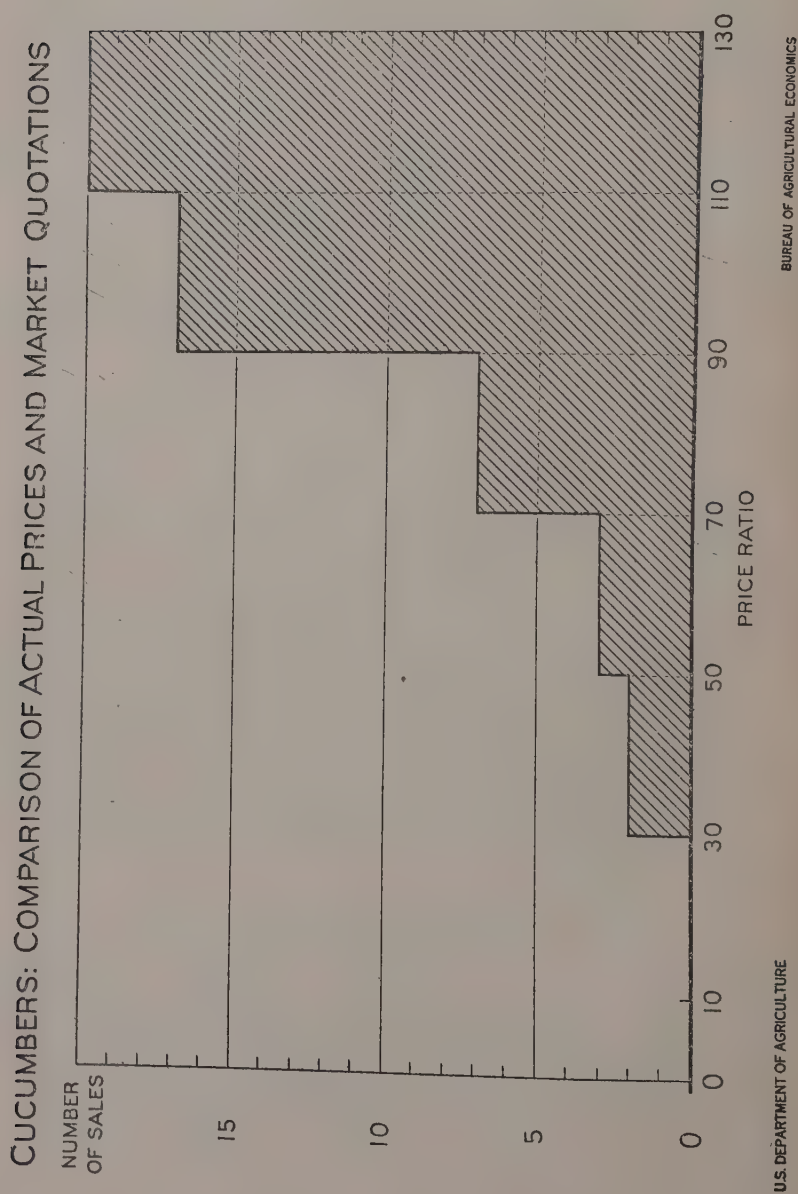
Cucumbers, No. 1 from \$4.00 to \$5.00.

Fancy \$5.50.

This type of quotation probably covers the actual price situation as well as it can be done. The hot-house cucumber market is more difficult to quote than the asparagus market

¹ The mean percentage price was 102.0 and the standard deviation was 29.2.

FIGURE 10



or the tomato market. There is a large volume of No. 1 or Fancy cucumbers on the market. There is also a considerable volume of cucumbers of poorer quality. The market must be quoted in such a manner as to include a considerable part of the sales of these poorer cucumbers. The market reporter must use his own judgment as to the fairest price to report. The average of the actual prices in the sample was 102 per cent of the market quotation, which indicates that the market report gave a fair indication of the average prices actually received. A larger sample would be necessary in the case of cucumbers to justify any real conclusions, but it is probable that the range in prices included in the quotation has covered the market as well as it could have been covered without a system of definite grades on which to base the report.

THE NEED FOR GRADES AS A BASIS OF MARKET QUOTATION

From this short discussion it will be seen that, in general, the market quotations have been a fair statement of the prices at which the largest volume sells. There is in most cases a great deal of variation in the actual prices due to variations in quality. The fact that any individual farmer may consistently get prices either higher or lower than the market quotation does not prove that the quotation is wrong. It shows only that that individual is selling a product which is of better or poorer quality than the quality of the greatest part of that product.

The only quotation which can adequately cover the variation in prices is a quotation on definite standard grades. A quotation on U. S. No. 1 Green Mountain potatoes from Maine or on Massachusetts Standard A Grade McIntosh apples is more than a statement of the level of market prices for potatoes or apples. The Special Apple Report issued by the Massachusetts Department of Agriculture is able to re-

port practically the whole range in apple prices without being indefinite because the report is based on grades which are uniform throughout the state and are known by all producers. It does not mean much to say that on September 23, 1927, the apple market in Boston was from \$1.00 to \$3.25 per bushel. But a report which reads:

McIntosh—A Grade 3 inches, layer pack, mostly \$3.00,
few \$3.25, few Fancy higher.
A Grade 2-¾ inches, layer \$2.75-\$3.00,
few higher and few as low as \$2.50.
A Grade 2½ inches, layer, mostly \$2.25-
\$2.50, few best higher.
A Grade 2¼ inches, layer \$2.00-\$2.25
B Grade, hand picked and some drops, layer,
mostly \$1.50-\$2.00
Few A and B mixed \$2.50.
Unclassified hand picks and drops, Jumble
\$1.25-\$1.50, some poorer, railroady, low
as 50 cents.

describes the situation fully and accurately and there is no misunderstanding among growers or dealers as to the meaning of such a report.

The reason that market reports on most nearby produce cannot be so detailed is that there are no standard grades in common use. Until such grades are adopted, the reporter is forced to judge for himself what quality shall be No. 1. He can report the range in prices by quoting the price of No. 1, the price of the best quality, and the price of poor quality.

The grading program which has been started under the authority of the new grading laws in the New England States will help considerably in making market reports more understandable.¹ It will soon be possible to set up definitions

¹ See Massachusetts laws, chap. 270, "To provide for establishing grades and standards for farm products," similar laws have been passed in four other New England states.

of such terms as "Fancy", "A Grade" and "No. 1". Where such terms are seen in the market reports, the grower and the dealer will both understand the reports better.

The length of the market reports, and therefore the detail in which prices are reported, is limited by the expense of getting, transmitting, and publishing quotations. Also from the news standpoint, the papers are not interested in a very detailed report. Therefore, most market reports include only a few quotations for each commodity which the reporter believes cover the bulk of the sales. A few states have experimented in the last few years with more complete reports to cover sales by varieties and grades of certain commodities. Examples of such reports are the Massachusetts Department of Agriculture's special apple market report and the commodity report of the New Jersey Department of Agriculture.

CHAPTER IX

THEORETICAL ASPECTS OF THE STUDY

THE last few pages have shown that this study has produced certain results which are practical and useful. The discovery of the important quality factors which influence the prices of any commodity has a direct bearing upon the method of producing and marketing that commodity. From this standpoint the present study has given the growers of asparagus, tomatoes and hot-house cucumbers vital facts concerning the demand for their products. Similar studies should be able to discover like facts concerning the demand for other commodities. It remains to be seen whether or not studies of this kind can add anything to economic theory.

It must be admitted at the start that the present study alone is not enough to do more than to indicate a possible method which may be useful in further research in the theory of prices, and to suggest a few of the objectives of such studies. The theoretical aspects of the present study were largely incidental. The study was undertaken with the simple and practical purpose of discovering facts concerning the market demand for certain vegetables. No attempt was made to carry out a broad piece of research work such as would be necessary in order to make a relatively complete analysis of the causes of price changes, and to discover general tendencies or laws. On the other hand the study was definitely limited in scope in order to focus the entire analysis upon the influence of certain physical characteristics on the prices received for three vegetables.

DEFINITE RELATIONSHIP BETWEEN QUALITY AND
MARKET PRICES

In spite of its narrowness in scope the present study does perhaps permit some generalizations in regard to prices. There is a distinct tendency for market prices of many commodities to vary with certain physical characteristics which the consumer identifies with quality, and the relation of these characteristics to prices may in many cases be fairly accurately determined by statistical analysis. If this generalization be accepted as true, it opens up a field in the theory of prices which has been practically untouched. It has already been remarked that the price theories up to the present time have been limited almost entirely to the explanation of the causes of day to day or year to year changes in average prices, price quotations, or price of a particular grade of a commodity. The causes of the variation in prices of a commodity at a given time and place have received little attention from economists. It has been demonstrated in the case of certain vegetables (and the statement will hold true for practically all agricultural commodities) that the type of price variation due to differences in the quality and appearance of the individual lots is important, and also that it is possible to discover a number of the most important causal factors, and to estimate the relation of these factors to the market prices. There is reason to believe that similar studies will be able to add greatly to present knowledge of the quality factors involved in the market prices of other commodities.

TYPE OF FACTORS WHICH DETERMINE PRICES

It is impossible at the present time to generalize very much concerning the type of factors which influence prices. Two general tendencies might be mentioned, however. The first tendency is that the factors which have the greatest influence on prices are those which are identified in the minds of the

buyers with quality. Green asparagus is identified in the consumer's mind with tenderness and freshness. Firm tomatoes, free from growth cracks, appeal to the consumer's appetite much more than do soft, misshapen tomatoes. Long, slender cucumbers are identified with crispness, mild flavor, and freedom from large seeds. These are the factors which appeal to buyers. They are the only indication the consumer has of the quality of the products he buys. It may be true that these factors do not in all cases indicate superior quality. For example, the Boston market has a distinct preference for red apples, and will not pay high prices for green or yellow varieties in spite of the fact that there are many green and yellow varieties of considerable merit. This preference may be explained by the fact that two of the most common and best varieties of apples produced in New England—McIntosh and Baldwin—are red. Consumers like these varieties, but seldom ask for them by name. Red apples are associated, rightly or wrongly, with good quality, and, therefore, consumers pay a premium for red apples. In general, consumers know little about the varieties of the products they buy. They buy on appearance, but the factors which they consider in making their purchase are those factors which they associate with quality.

The second tendency is that factors which have an important influence on prices must also be easily seen by the immediate buyer. This fact has been demonstrated in the study by Benner and Gabriel of the retail price of eggs in Wilmington, Delaware. This study indicated that the important quality factors influencing retail egg prices were first, cleanliness; and, second, size. The interior quality of the egg had practically no influence on prices in spite of the fact that this factor is undoubtedly more important than all others in the minds of consumers. The consumer has no way of judging the interior quality of the eggs he buys.

He can see whether an egg is dirty or clean, or whether it is large or small, but he cannot judge whether an egg is fresh or old, good or bad, until he breaks it. He has then paid his money. If the study had been made for eggs sold at wholesale and candled by the buyers the results might have been different. Or, if the study had analyzed the variation in the prices of eggs sold at retail under various brand names which met different quality specifications, it might be found that the consumer pays a premium for quality, but that the quality is judged by the brand of trade mark, which has established a certain reputation for quality.

NEED FOR FURTHER STUDY OF QUALITY DIFFERENTIALS

The study suggests the need of further investigations in the field in order to throw some light on other questions of price theory which have received little attention. In discussing the results of the present study with farmers and economists, it has often been remarked that it would be quite useful to discover not only the average quality differentials, (as was done in this study), but, also, the variability of these differentials and the reasons for changes in the premiums paid for quality. From a practical standpoint this is important, because the farmer and the dealer are interested not so much in the average premiums paid during the preceding seasons, as they are in the probable price differentials during the coming season. It also is important from the theoretical standpoint that some consideration be given to the causes of variation in the premiums paid for quality from day to day and from season to season.

It is probable that the amount of the premiums paid for the various quality factors is influenced, first, by the total supply of the commodity on the market, and, second, by the proportions of the commodity of the various grades and sizes. Other factors which may influence the amount of the

premiums include the purchasing power of consumers, the weather, and the amount of available substitutes. A more complete discussion of the theoretical aspects of quality as a price determinant should give some consideration to these factors. Further studies of this kind are likely to suggest other aspects which need attention. It will be necessary, however, to make a number of detailed studies of these questions before they can be adequately discussed. For the present, they will merely be noted as worthy of some study, and some more attention will be given to the first two factors; first, the total supply of the commodity, and, second, the proportions of the supply among the various grades.

THE RELATION OF QUALITY DIFFERENTIALS TO TOTAL SUPPLY OF THE COMMODITY

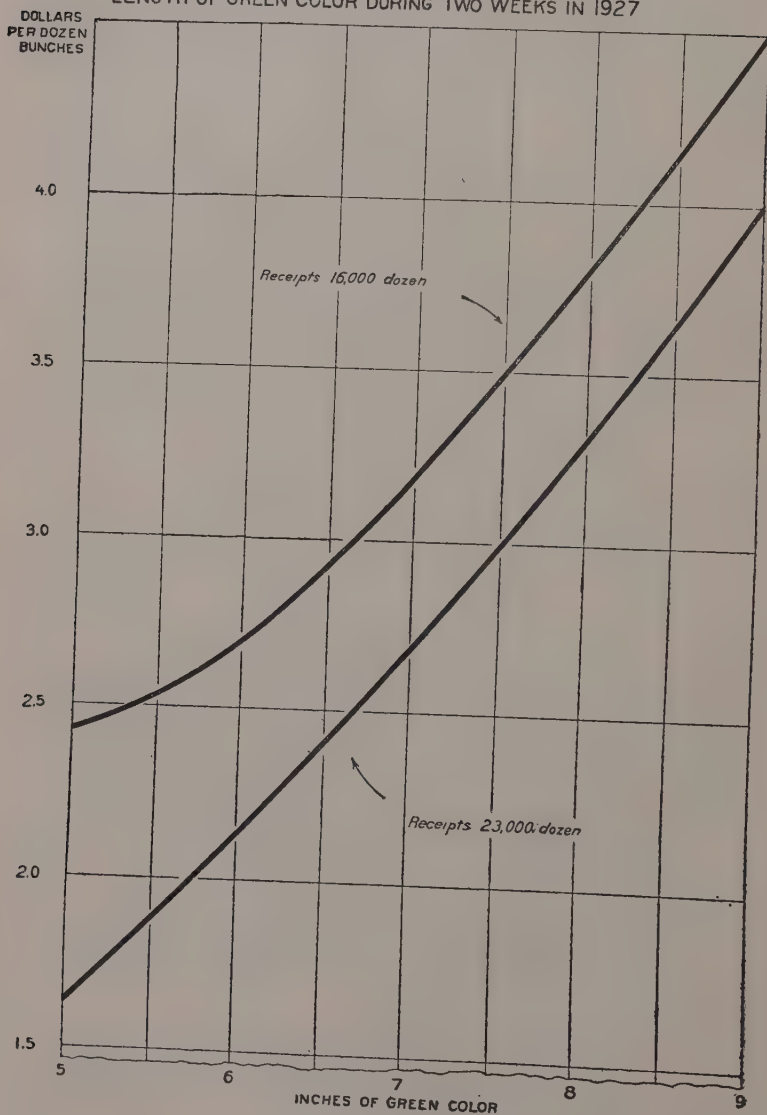
In making this study, the influence of supply on prices was eliminated, (at least as far as possible), by expressing the actual prices received for the various commodities as percentages of a market quotation. In this way the field of investigation was definitely limited to a study of the quality factors which caused individual lots of each commodity to sell at prices above or below the average price in the market. In a similar way, economists who have analyzed the influence of supply on prices have first eliminated variations in quality by studying market quotations of a uniform grade of a commodity. It is probable that supply and quality have a joint effect on prices of commodities which is not fully brought out by such analyses. By eliminating the influence of supply factors, it is possible to arrive at some measure of the average influence of certain quality factors, but it is likely that this average does not remain constant with varying market conditions.

It was thought that a further analysis of the data obtained in connection with this study might indicate, in a general

way, the relationship between premiums paid for quality and the total supply of a commodity on the market. Since the Massachusetts Department of Agriculture publishes daily estimates of the receipts of local products by truck in Boston, it would seem that some study of these data on receipts, together with the records obtained in this study on quality factors, might yield some results. After a good deal of experimenting, however, it was found that the data were inadequate for this type of analysis largely because they covered only one season for each commodity. The seasonal variation in demand was so great that very little relationship was found between receipts and prices.

While the study did not permit any general conclusions concerning this aspect of prices, observation of the original records does show in a number of cases that the size of the premiums paid for quality varies positively with the receipts on the market. This tendency is shown rather clearly in the case of asparagus. During the week of May 14 receipts of local asparagus in Boston were 16,000 dozen bunches. The following week receipts increased to 23,000 dozen bunches, an increase of about 44 per cent. During this period local receipts made up practically the total supply. These two weeks are ideal for a comparison of asparagus prices. There was a marked difference in the total supply without any change in the origin of the supply. The period is so short that there was not likely to be any great change in demand.

The original records for these two weeks were retabulated. The relationship between green color and prices during the two weeks is shown in Figure 11.

NATIVE ASPARAGUS: RELATION OF MARKET PRICES TO
LENGTH OF GREEN COLOR DURING TWO WEEKS IN 1927

RELATION OF PREMIUMS FOR GREEN COLOR ON ASPARAGUS
TO TOTAL RECEIPTS DURING TWO WEEKS

It will be seen that prices during the week ending May 14, when receipts were 16,000 dozen bunches, were considerably higher than during the following week, when receipts were 23,000 dozen bunches. There was a drop in prices from one week to the next in all qualities of asparagus, but it will be noted that the decrease in prices was greater in the case of asparagus with a small amount of green color than in the case of asparagus with a large amount of green color. The price of asparagus with five inches of green dropped from about \$2.40 per dozen bunches during the first week to about \$1.55 during the second week. The price of asparagus with nine inches of green color dropped from \$4.50 per dozen bunches to \$4.00 during the same period. In other words, the price of the cheaper asparagus dropped about eighty-five cents while the price of the more expensive asparagus dropped only fifty cents.

The comparison is more striking when stated in terms of percentage. The price of asparagus, with five inches of green color, was about fifty-five per cent higher in the first week than in the second week, while the price of asparagus with nine inches of green color was only twelve and a half per cent higher.

CONCLUSION COINCIDES WITH MARKET OPINION

This comparison would indicate that the prices of asparagus with a large amount of green color are more stable than the prices of asparagus with a small amount of green color. This conclusion is strengthened by the comments of the commission men who sell asparagus. There are in the market a few well-known brands of asparagus with nine inches of green color. Commission men state that the prices they can get for these fancy brands do not vary to any consider-

able extent with changes in the supply situation. On the other hand, when the market is glutted, the prices of the lower grades must be reduced drastically in order to move them. A study of the prices of New Jersey cobbler and giant potatoes ¹ made in 1923 indicates a similar tendency for the premiums paid for better varieties to increase as total supplies increase.

Personal observation in a number of wholesale fruit and vegetable markets and the comments of experienced market reporters have led the writer to believe that this tendency for quality differentials to increase with increases in the total supply on the market is common, if not universal. When a commodity becomes scarce and prices are high, many consumers reach a limit beyond which they will not go in order to get superior quality. When supplies increase, and the market becomes glutted, prices are so low that consumers feel they can afford the best quality. Observation of the strawberry market in any large northern city will show that when Florida berries sell at a dollar a box, it is almost impossible for the storekeeper to get much more than a dollar for berries of a quality much superior to the average. But when the prices of ordinary local strawberries dropped to eight cents per box in Boston, it was found that many of the better packs sold at fifteen cents and found ready buyers. In other words, the market was willing to pay a premium of almost one hundred per cent for strawberries of superior quality when supplies were heavy, but is usually unwilling to pay very high premiums when supplies are light and average prices are high.

It is impossible here to demonstrate that this tendency is universal. It should merely be noted that here is an interest-

¹ Frederick V. Waugh, "Factors Influencing the Price of New Jersey Potatoes on the New York Market," *Circular No. 66*, New Jersey Department of Agriculture.

ing and important aspect of price theory which is usually not noticed by economists because their attention has been focused on other problems. Further study along this line should be profitable. In order to make such a study, it might be necessary to obtain records of the quality, total supply, and prices of a commodity over a series of years in order to compare the premiums paid for quality factors during years of heavy and light supply. This may not be necessary if the supply of the commodity studied varies considerably during the season, and the seasonal variation in demand can be satisfactorily eliminated. It might be possible to get results of some value from studies of market quotations and auction records using the average prices obtained for the various grades during periods of heavy and light supplies.

THE RELATION OF QUALITY DIFFERENTIALS TO THE
PROPORTIONS OF THE SUPPLY OF A COMMODITY OF
VARIOUS QUALITIES

The amount of the premium paid for a particular quality of any commodity may depend not only upon the total supply of that commodity on the market, but also upon the proportions of that supply of the various grades or qualities. The quality of most farm products varies from year to year. Annual differences in weather conditions, and in the prevalence of insect pests cause certain crops to be of exceptionally high quality while other crops are practically worthless. This fact suggests the interesting and important question, "Will the premium paid for products of high quality tend to remain constant, or will it change with variations in the proportion of the different grades of qualities on the market?"

In order to answer this question, it will be necessary to study the premiums paid for quality factors over a number of seasons during which the quality has varied considerably.

The present study gives no answer as it is based on a single season. It seems probable, however, that the amount of the premiums paid for quality factors does depend to some extent on the amount of each quality in the market. Let us assume, for example, that during a particular season the market is well supplied with asparagus, but that the quality in general, is poor, and that only a few of the best growers are able to supply the market with asparagus of the best grade. The large supplies of asparagus would probably tend to keep the general level of market prices down, but the "fancy trade", the exclusive hotels and restaurants, and the retail stores in the fashionable residential sections, probably would continue to insist on the best quality. This would result in a brisk competition among buyers for the limited quantity of the better grades of asparagus and naturally would keep the prices of these grades at a relatively high level. In this case the premium paid for quality would be increased. On the other hand, if, during a particular period, most of the asparagus were of exceptionally good quality, it is likely that the premium received for the quality factors would be smaller.

It is even possible that a careful study of this question would show that changes in the proportion of the various qualities on the market may occasionally result in changes in the qualities which receive the highest prices. For example, let us assume that an apple which is three inches in diameter normally sells at the highest prices. It is entirely possible that a season of especially large apples might induce certain buyers to pay a premium for the smaller sizes. The export buyers, especially, prefer the smaller sizes, and if the supply of these sizes were short enough, the result might be that for that particular year, a two and three quarter inch apple or a two and one half inch apple would outsell a three inch apple.

It is probably safe to say that the premium paid for any

particular quality factor will depend somewhat on the proportion of that quality on the market. The importance of this consideration depends on the extent to which the buyers consider the different grades and qualities as different commodities. If certain buyers should insist on three inch apples, and certain others should be interested only in two and one half inch apples the two sizes might be considered almost as different commodities. In this case the price of the three inch apples and the two and one half inch apples might be determined independently by different sets of forces. Actually, however, this is not the case. It is true that buyers have certain fairly definite preferences, but it is seldom that such preferences are clearly defined. The quality of fruits and vegetables varies by minute and imperceptible degrees. In few cases are the quality factors actually measured by the buyer. Rather, he looks over the various lots, judges the size, shape, condition, color, pack, etc., in a general way, considers the prices asked, and finally purchases the lot which, all things considered, he thinks is the best buy. While he has certain preferences in regard to quality, a good deal of substitution is possible. Therefore, the prices of the various qualities and grades are more or less mutually interdependent.

If the prices of the various grades and qualities are mutually interdependent, it is likely that an analysis similar to that of the mathematical school of economics would lead to interesting results.¹ This school of economists has held that the prices of all commodities are mutually interdepend-

¹ If complete records of the supplies of the various commodities and the resulting prices were available over a sufficient period of time, it might be possible to discover the joint effect of quality factors and the percentage of each quality on prices by means of a "regression surface". The method of determining such a joint relationship is discussed by M. J. B. Ezekiel, "Determination of Curvilinear Regression Surface in the Presence of Other Variables," *Journal of the American Statistical Association*, September, 1926.

ent, and has been concerned with the theoretical implications of such interdependence. Statistical studies of market prices to date have, however, been aimed primarily at measuring factors which affect single commodities, and it has been shown that the prices of many commodities can be independently determined with a fair degree of accuracy. In fact, a number of studies have shown that the prices of many of the commodities are influenced only slightly by the prices of other commodities which might be substituted. But, in the case of various qualities of the same commodity it is evident that the problem is somewhat different. The fact that the quality factors vary by imperceptible degrees from the highest to the poorest quality makes it obvious that the possibilities of substituting one quality for another are much greater than of substituting one commodity for another. This necessarily results in a closer relation between the prices of the various qualities.

If it is possible to obtain records of the supply of the various grades and qualities of a commodity on the market, together with the prices received for each grade and quality over a longer period of time, it may be possible to reach some conclusions in regard to this aspect of price theory. A recent study of the New York peach market ¹ has shown some relationship between the premiums paid for certain varieties and sizes and the supply of these qualities and sizes. Kuhrt, in his analysis of wheat prices,² also discusses reasons for changes in the relation of protein content, dockage, and test weight to prices. Further studies along this line should be profitable.

¹ Harry S. Kantor, "Analysis of the N. Y. Peach Market," New York Food Marketing Research Council, 1927, unpublished.

² W. J. Kuhrt, "A Study of Farmer Elevator Operation in the Spring Wheat Area," U. S. Department of Agriculture Preliminary Report, 1927.

THEORY OF QUALITY SIMILAR TO RENT THEORY

Doctor E. M. Burns, of Columbia University, has pointed out that the economic theory of rent accounts for differences in land values due to differences in the quality of land (including in the word "quality," the distance from market, etc., as well as the productivity of the soil). It should be possible to develop an economic theory similar to the rent theory to account for variations in the values of commodities in general at the same time and place. Such a development of the economic theory of value should bring economic theory into better agreement with the facts of the market.

CHAPTER X

A DISCUSSION OF METHODS OF MEASURING MARKET DEMAND FOR QUALITY

THERE are two possible methods of discovering the qualities of a commodity which determine its market value. The first, which has been in common use during recent years, is the so-called "demand survey". The second, which is used here, is the statistical analysis of records of inspection which provide the sales prices of individual lots of a commodity together with an accurate statement of certain qualities of the lot. The survey method is essentially the compilation and summarization of the likes and dislikes of a group of dealers or consumers for varieties, types, grades and qualities of a commodity as reported by individuals and obtained by personal interviews or by mail. A detailed questionnaire may be used or the dealer or consumer may be asked general questions and allowed to state his preferences in his own way. The statistical analysis of records of the quality factors and the market prices of individual lots of a commodity makes no attempt to discover the individual preferences of dealers or consumers, but measures the reaction of the market in general to quality factors in terms of prices. That is, instead of compiling the reported likes and dislikes of individuals, this type of statistical analysis attempts to estimate these preferences for the whole group of dealers or consumers in the market area by measuring the market-price differentials due to a number of quality factors.

While these two methods have as a common purpose the discovery of the types and qualities of a commodity which are demanded by the market, the type of material obtained by the two methods is likely to be quite different. For that

reason it may be of some value to summarize the advantages and disadvantages of the two methods, and to consider the value of each in adding to present knowledge of market demand for quality.

ADVANTAGES OF THE SURVEY METHOD

Variety of Factors can be Included

There is no limit to the amount of detail which may be obtained by the questionnaire methods. In a recent survey of apple demand in New York City ¹ consumers were asked, "Why do you eat apples"? A variety of reasons were given and a summary of the answers to this question gives a picture of the opinions of consumers regarding apples which could have been obtained in no other way. Such general questions as the one above or, "What qualities do you consider important in apples," are likely to enable the student to arrive at some measure of the importance of a large number and a great variety of factors which influence market demand.

A large number of factors may be specifically included in the questionnaire. The consumer or the dealer may be asked to rate the importance of a number of quality factors. For example, the student who is interested in the market demand for apples may ask the consumer or dealer to estimate the relative importance of variety, pack, taste, color, size, insect injury, deformity of fruit, uniformity of size, and so forth, mentioning specifically all the factors he can think of which may have some importance. In this way, it is possible to get some sort of a summary of the importance of as many factors as the student wants to include.

Perhaps the most important advantage of the survey method is that it is able to consider factors which are diffi-

¹ Earl R. French, *Consumer Preferences for Apples in New York City*. To be published soon by the U. S. Bureau of Agricultural Economics.

cult to measure statistically, such as taste, smell, freshness, texture, and firmness. The statistical analysis of inspection records is unable to include such factors as these unless some satisfactory measure can be made for them. It may be possible to get a fairly satisfactory measure of firmness by recording for each lot the percentage classed as firm, fairly firm, slightly soft, and very soft. While this involves the judgment of the inspector, rather than actual statistical measurement, the analysis of tomato prices reported here shows that some rather definite conclusions can be drawn from such a classification. It may be possible in the future to measure firmness in a more accurate manner. There is, for example, a patented device for measuring the firmness of apples. This device is commonly used by storage men to indicate how their apples are "holding up" in storage. Perhaps it would be possible by means of a similar device to measure the firmness of other commodities. It probably will, however, be always impossible to find a satisfactory statistical measure of many quality factors which may be important in their influence on market demand. For example, two of the most important quality factors in the case of lettuce are probably the compactness of the head and the freshness of the product. It is doubtful if these factors can be measured satisfactorily for the purpose of statistical analysis. Such factors as these can be studied only by the survey methods.

Opinions and Comments may be Helpful

Closely associated with the advantage of including a large number and variety of factors is the advantage of getting general comments from consumers or dealers. These comments may be suggestions for improving the type of pack or the grading methods. They may bring to light a demand for certain types of products which are not commonly found on the market. Such suggestions and comments may be helpful.

Preferences can be Summarized by Groups

It is sometimes desirable to study the preferences of consumers by groups classified according to income, nationality, or profession. Since this statistical analysis of records of sales prices and quality of individual lots of a commodity provides only a statement of the reaction of the entire market, it does not make possible such a summary of the demand of particular groups.

DISADVANTAGES OF THE SURVEY METHOD

Quantitative Measurement of the Influence of Various Factors is Almost Impossible

The tabulation of statements of consumers or dealers of the qualities which are important in influencing their purchases makes it possible to arrive at a long list of factors which are desirable or undesirable. It is usually not possible, however, to derive from such a tabulation any satisfactory measure of the influence of these factors on market prices nor even to list them in the order of their importance. The nearest approach to a quantitative measure which can usually be made is to compare the number of consumers or dealers who mention the various factors as being important. If ninety percent mention size as being an important factor, while sixty percent mention uniformity of pack and forty percent mention freedom from insect injury, the conclusion is commonly drawn that size is more important than uniformity or insect injury. Even such a general conclusion as this, which does not make any estimate of the market value of any of these factors, may not be warranted. It may be that most of the consumers do not know what is meant by insect injury and, therefore, do not mention it in answer to the questionnaire. While they may not have ever heard of curculio stings or coddling moth damage, they may know when they see apples damaged by these insects that the

quality is poor, and these factors may have an importance in their effect on consumer demand which is far greater than the answers to a questionnaire would indicate.

This is the most serious disadvantage of the questionnaire method. The producer wants and needs a definite, quantitative measure of the influence of quality factors. If consumers say they want long, slender cucumbers, the producer is interested only if this demand is reflected in a premium which will pay him for producing this type of a product.

Questions may Suggest Answers

It is difficult to eliminate the preconceived notions of the student in making out a questionnaire. The student wants answers to certain questions which he considers of some importance, and usually he gets some kind of answer to the questions he asks. Perhaps some of these questions may actually be of little importance in the market. In a recent study of demand for apples in Connecticut,¹ consumers and dealers were asked whether they preferred apples of uniform or mixed sizes. Most of them reported that they preferred uniform size. Yet, it is possible that the premiums these consumers and dealers actually were willing to pay for uniformity were small, and that this factor did not influence them in any great degree in purchasing apples. Because the question was asked, most of those questioned answered it, and a large proportion of them said they wanted uniform sizes. There may have been many factors which were not mentioned in the questionnaire and some of these may have had considerable influence on demand.

Survey Usually shows Quantities used but not Prices

A real measure of demand includes the element of price. The demand for a commodity is not measured entirely by

¹ I. G. Davis, F. V. Waugh and Harold McCarthy, "The Connecticut Apple Industry," Connecticut Experiment Station *Bulletin* No. 145, 1927.

the quantity of that commodity consumed, but, rather by the amounts which consumers will buy at given prices. The usual form of questionnaire indicates only the types or qualities of a commodity which are purchased and does not show adequately the relationship of these qualities to prices. When the questionnaires are tabulated according to the incomes of consumers, it may be found that certain classes buy mostly the lower grades. This does not mean that they prefer these lower grades to the higher grades.

Individual is Unable to Analyze His Own Demand

While it is apparent that quality factors have a decided influence on demand, dealers and consumers ordinarily do not consider each factor separately in judging quality. If he is asked why he will pay more for one box of tomatoes than another, the consumer usually can answer only in general terms. He may say that one box is fresher than the other, or it looks fancier, or merely that it is of better quality. An experienced salesman in a commission house can usually give a more satisfactory and detailed answer, but even he has never attempted to analyze the relative importance of the many quality factors.

A recent study of the quality factors influencing the prices of McIntosh apples in Boston,¹ following the same methods used in the present study, was able to explain a large part of the variation in market prices in terms of the size, pack, uniformity, amount of insect injury, amount of scab, and some other factors. The experiment was tried by asking the salesmen who handled these apples to estimate the relative importance of these factors and their average influence on prices. It was found that there was considerable variation in the opinions of these salesmen and that most of them were

¹ Julius Kroeck, *McIntosh Apple Study*, Massachusetts Department of Agriculture, 1928.

unwilling to make a definite answer to the questions, because they said frankly that they had never attempted such a detailed analysis and could at best make guesses which might be quite inaccurate.

It is not surprising that even the best informed salesmen are unable to analyze in detail the influence and relative importance of the various quality factors. Probably they would also be unable to estimate accurately the relation of potato prices to production in different parts of the country, the general level of wholesale prices, business conditions and other factors. In order to get measures of this kind, it is usually necessary to get records of prices and of the various factors which may have influenced these prices, and to analyze them statistically.

ADVANTAGES OF STATISTICAL ANALYSIS OF RECORDS OF INSPECTION AND PRICES

Influence of Factors can be Measured Quantitatively

The most important advantage of measuring the demand for quality by the statistical analysis of records of inspection and prices is that this method makes possible a more accurate quantitative measure of the relative importance of the various factors and their influence on prices. As has been demonstrated in this study, it is possible to discover the net influence of each of a number of quality factors and to state this influence in terms of dollars and cents. It should be realized, of course, that no such measure is absolutely accurate, and that the results apply only to a particular market during a particular period; but, for that market, and during that period, it is valuable both from the standpoint of the producer and from the standpoint of the economist to measure these relationships as accurately as possible and to arrive at a definite, quantitative statement of them. Without such a statement, it is possible only to list the factors which are desirable and those which are undesirable.

Preconceived Notions of the Student tend to be Eliminated

If the factors studied are in such physical terms as inches, pounds or numbers, the investigator can measure each factor accurately. The results may be influenced to some extent by the investigator choosing the lots of the commodity which he inspects. This influence can be largely eliminated, however, by the inspection of all the lots of a commodity handled by a particular house each day or by taking at random the first lots which the inspector sees.

If care is taken to obtain a random sample, and if the qualities studied can be accurately measured, rather than depending upon the judgment of the investigator, the results will not be influenced to any great degree by preconceived notions.

DISADVANTAGES OF STATISTICAL ANALYSIS OF RECORDS OF
INSPECTION AND PRICES*Many Quality Factors can not be Measured*

The greatest disadvantage of the type of analysis used in this study is that the student is limited to studying those quality factors which he can measure. This has already been discussed rather fully. It is perhaps sufficient to note here that certain commodities are not well adapted to studies of this kind. It would be difficult to find a measure of the quality factors which have an important influence on the prices of spinach, lettuce or parsley.

Group Preferences can not be Studied Advantageously

The statistical analysis of records of inspection and prices does not make possible a statement of the preferences of particular groups classified by incomes, nationalities or occupations. From the practical standpoint, this is not a serious disadvantage, because the producer is interested particularly in the amount of premium the whole market will pay for

quality rather than in an attempt to measure variations in demand among various groups of consumers. To the economist who is interested in a more detailed analysis of demand, it is a real disadvantage.

NEED FOR BOTH METHODS

It is evident from this discussion that the two methods supply data of a different nature, and that they supplement rather than duplicate each other. The statistical analysis of records of inspection and prices makes it possible to discover the relative importance of a number of measurable quality factors and to estimate in terms of dollars and cents their influence on market prices. The survey, on the other hand, provides a great deal of useful information of a more general nature, and is able to consider such factors as taste and smell which are not adapted to statistical measurement.

The ideal study of demand should use both methods. A survey which calls for general comments of consumers and dealers will show the factors which they consider in buying their supplies. Some of these factors may be adapted to quantitative measurement. If so, it is possible to get in a short time and without much expense, a record of the sales prices and a record of the quality factors involved in a number of sales of the commodity studied. An analysis of these records will make possible a more definite, quantitative statement concerning the importance of these quality factors as an influence on demand. Usually it will be necessary for the student to make a survey of this kind before he begins a statistical study of the relationship of quality to prices. Without such a survey he may not know what qualities to measure.

There is a definite field for the method used in this study. It provides a type of information which is not covered by the survey and which is distinctly useful.

CHAPTER XI

NOTES ON STATISTICAL ANALYSIS

The results of this study have been set forth in a rather simple manner. No attention has been given so far to the adequacy and reliability of the data nor to the exact interpretation of the statistical results. The average influence of each quality factor has been stated, and certain conclusions have been drawn concerning the bearing of such average measurements on production and marketing methods, on grade requirements and market reporting, and on economic theory in general. It remains to examine the data in a critical manner in order to state the relationships between the quality factors and prices in a more exact manner.

The appendix which follows this chapter is a summary of the original records of inspection and prices, together with a summary of all the statistical measurements used in the analysis of these data. The statistician will find in this appendix in a few pages an exact statement of the statistical results of the study. The present chapter will be devoted to a discussion of the meaning of these statistical measurements.

SOURCE OF DATA

The records of sales prices and qualities of asparagus, outdoor tomatoes and hot-house cucumbers were obtained by investigators of the Massachusetts Department of Agriculture from inspections of these vegetables in the wholesale market district around Faneuil Hall, Boston. The inspections were usually made early in the morning before the commodities were sold. A record was kept of the lot number

and the following day the investigator obtained from the books of the commission house the average price at which each of these lots sold. The attempt was made to get as near as possible what is known as a "unit price", that is, the price at which one box of the commodity was sold. This eliminated a considerable amount of variation in prices due to discounts to larger buyers.

PERIOD COVERED AND NUMBER OF INSPECTIONS

The inspections of asparagus cover the period from May 6 to July 2, 1927; those of out-door tomatoes, the period from May 19 to November 10, 1926; and those of hot-house cucumbers the period from May 5 to October 16, 1925. In the case of asparagus and out-door tomatoes practically one entire local marketing season was covered. Since hot-house cucumbers are produced throughout the entire year, the study of cucumber prices covers only about half of one season. The investigator went to the market practically every morning during the periods stated, and made a few careful inspections each day. The reports are, therefore, well spread out over each period, and are not likely to be unduly influenced by temporary conditions of abnormally high or low quality or of a general scarcity or abundance of the commodities.

In this analysis 200 records of asparagus quality and prices were used; 370 records of out-door tomatoes quality and prices; and 49 records of hot-house cucumber quality and prices. All records made by the inspectors were used, except that in the case of tomatoes a number of records concerning hot-house and shipped-in tomatoes were discarded, as were a few records of out-door and shipped-in cucumbers. It was thought best to limit this analysis to one particular type of each product, and, as the locally produced tomatoes and cucumbers make up the bulk of the Boston supply, and as they are of most interest to local producers, the locally produced commodities were chosen for a separate study.

METHOD OF ANALYSIS

The records were tabulated and analyzed by multiple correlation methods.¹ The results given in Parts IV, V, and VI show the average relationship between quality factors and prices as estimated by the regression, determination and correlation coefficients.

ANALYSIS OF ASPARAGUS PRICES

A sample inspection record for asparagus is shown on page 150. There were not enough reports of crooked stalks and frayed tips to allow a statistical analysis of these factors. For that reason the analysis was limited to finding the influence on prices of three factors; first, the length of green color; second, the number of stalks to the bunch; and, third the variation in size within the bunch. The length of green color was measured in inches. The number of stalks per bunch was counted. The variation in size within the bunch was calculated from a record of the percentages of each lot which were of various diameters. The measure used was the quartile coefficient of dispersion, or $\frac{(Q_3 - Q_1)/2}{M}$, or one half

the difference between the third and first quartiles divided by the median. While this measure is not exact, it indicates well enough for the purposes of the present study the relative amounts of variation in size among the lots studied. The unit sale price was expressed as a percentage of the top quotation in the Farmers' Produce Market Report of the Massachusetts Department of Agriculture for the day on which each lot was sold. This was done in order to eliminate price variations due to seasonal changes in the prices received for asparagus of average quality. These records of green color,

¹ No complicated or unusual methods were used in this study. See Frederick C. Mills, *Statistical Methods*, 1925, chaps. x, xii, xiii and xiv for an exposition of the methods used.

number of stalks, variation in size, and percentage prices were then tabulated and analyzed.

The statistical summary on page 144, of the appendix gives the following coefficients of regression:

$$\begin{array}{rcl} b_{12.34} & = & + .13826 \\ b_{13.24} & = & -1.53394 \\ b_{14.23} & = & - .27553 \end{array}$$

These coefficients of regression should be interpreted to indicate the average amount of variation in the dependent factor (percentage price) which was associated with a unit change in each independent factor, (green, number of stalks and variation). Thus, $b_{12.34} = +.13826$ indicates that each additional one hundredth of an inch of green color was associated with an increase of .13826 in the percentage price. The average amount of green color reported was 5.8875 inches. The average percentage price was 90.095. The price percentage associated with asparagus which had one inch more green color than the average, or 6.8875 would be $90.095 + (.13826 \times 100) = 103.921$. In like manner, $b_{13.24} = -1.53394$ indicates that each additional stalk per bunch decreased the percentage price by 1.53394, and each additional unit of variation decreased the percentage prices by .27553.

These measures have been put in more understandable form by multiplying the regression coefficients divided by one hundred by the average of the top market quotation, which was used as the basis of calculating the percentage prices. This converts the estimate of change in the percentage prices associated with each quality factor to terms of dollars and cents. Thus, when the market quotation was at the average level for the period (\$2.782), an additional one hundredth of an inch of green color was associated with an increase of $\frac{.13826}{100} \times \$2.782 = \$0.003845$ in prices, or each inch of green

color was associated with 38.45 cents increase in price per dozen bunches. In like manner, each additional stalk to the bunch was associated with a decrease in price of 4.6 cents, while each increase of one unit in the quartile coefficient of dispersion in the diameter of stalks within the bunch was associated with a decrease of .765 cents.

It should be noted that in expressing the original prices as percentages of the market quotation it has been assumed that the percentage price change, rather than the absolute change in dollars and cents will remain constant throughout the season. Therefore, the number of cents change in prices associated with one unit change in the various quality factors is a valid measure only as an average for the whole season, or for a period when the quotation is at its average for the season.

The relative importance of the three quality factors in their influence on prices may be expressed by their determination coefficients, which will be found in the summary in the appendix. These coefficients may be interpreted as indicating the proportion of the squared variability of the dependent factor which is attributed to each dependent factor.¹ They show that variation in green color accounts for 41 per cent of the squared variability in the percentage prices, while variations in the number of stalks per bunch account for 14 per cent, and variations in the coefficient of dispersion in size account for 2 per cent. The sum of the coefficients of determination is .57524, indicating that 57.524 per cent of the squared variability in the percentage prices is accounted for by the three factors studied.

The square root of the total determination coefficient gives

¹ For a discussion of the coefficient of determination as a measure of relationship, see B. B. Smith, "Correlation Theory and Method Applied to Agricultural Research," U. S. Department of Agriculture, *Mimeograph Report*, August, 1926, p. 55.

the coefficient of multiple correlation¹ which is .75838. This indicates the degree of relationship between the percentage prices and the three quality factors studied. Perfect correlation would be indicated by a coefficient of 1.00000.

The standard error of estimate is 21.253, which indicates the degree of accuracy with which the price percentages can be estimated from the regression equation: $x_1 = +.13826 x_2 - 1.53394 x_3 - .27553 x_4$. The relative reliability of estimating the percentage prices by the mean value of X_1 , and by the regression equation may be judged by comparing the standard deviation of the price ratios, (or σ_1) with the standard error of the estimate (or $S_{1.234}$). These measures are:

$$\begin{array}{rcl} \sigma_1 & = & 32.613 \\ S_{1.234} & = & 21.253 \end{array}$$

It is apparent that, while the regression equation has not accounted for all the variation in the price percentages, it provides a much more reliable estimate than does the mean value of X_1 .

The reliability of the regression equation as an estimate of the percentage prices may also be judged from the fact that, given a normal distribution of the price data, the probabilities are that 68 out of 100 percentage prices would fall within the limits $\pm S_{1.234}$ from estimates based on the re-

¹ The correlation coefficients given in the text indicate the mathematical relationships between prices and independent variables, and do not take into account the number of observations nor the number of independent variables. B. B. Smith, in the study quoted above, has suggested the following correction for the correlation coefficient which makes an allowance for both the number of observations and the number of independent

variables: $\bar{R}^2 = 1 - \frac{1 - R^2}{1 - m/n}$, where $\bar{R}$ is the corrected value of R ; m is the number of independent variables; and n is the number of observations. The values of R corrected by means of this formula will be found in the appendix. It will be noted that the corrections are all small.

gression equation; 95 cases out of 100 should fall within the limits of $\pm 2S_{1.234}$; and 99.7 cases out of 100 should fall within the limits of $\pm 3S_{1.234}$. In other words, if the percentage price of any individual lot of asparagus in this sample were estimated, from the record of green color, number of stalks to the bunch, and quartile coefficient of dispersion in diameter of stalks, to be 100 the chances would be 68 out of 100 that the actual percentage price was between 78.75 and 121.25.

ANALYSIS OF TOMATO PRICES

The analysis of tomato prices was similar to that of asparagus prices; the only differences being that more factors were included in the tomato-prices analysis and that in the case of these factors (day of the week, place grown and pack), the residuals of the percentage prices have been stated for individual days, towns and packs rather than assuming a constant increase or decrease throughout each series as arranged.

In making the following analysis the reported sales prices were first expressed as percentages of the average daily market quotation as calculated by Mr. W. A. Maloney, the market reporter of the Massachusetts Department of Agriculture. This average quotation was calculated by weighting each quotation according to the reporter's judgment of the proportions of each day's supply which was sold within the range of that quotation.

The regression coefficients on page 147, should be interpreted in the same manner as those for asparagus. Thus $b_{12\ 34 \dots 13} = -.03703$ should be interpreted as follows:

The mean percentage price was 111.24; while the mean value of the trend was 45.57. Therefore, on the forty-sixth day of the study the tendency was for tomatoes of the average quality reported in this study to sell at 111.24 per cent of the average market quotation. Thirty days later the ten-

dency was for tomatoes of similar quality to sell at 111.24 — $(30 \times .03703) = 110.13$ per cent of the average market quotation. This slight trend in the relationship of prices of tomatoes of average quality and the average market quotation may be attributed to a very slight, gradual improvement during the period studied in the average quality of tomatoes on the market.

The interpretation of the remaining coefficients of regression offer no difficulties, except that some further interpretation should be made of the case of the size and condition groups. In general, the coefficients of regression should be interpreted as the amount of increase or decrease in the percentage price associated with an increase of one unit of each factor. The sizes in each lot of tomatoes were reported as the percentage which were between one and two inches in diameter; the percentage between two and three inches; the percentage between three and four inches; and the percentage between four and five inches. The condition of each lot was reported as the percentage classed as very soft, soft, fairly firm and firm. The total of each size classification and the total of each condition classification was 100 percent. There was, therefore, perfect intercorrelation within each of these groups; the percentage of tomatoes in any three size groups determined exactly the percentage in the fourth group, while the percentage in any three condition groups determined exactly the percentage in the remaining group. Such complete intercorrelation of the dependent factors is likely to cause some difficulty in the statistical analysis of the results, and in their interpretation. For that reason, in tabulating the data for analysis, as will be seen in the summary of the original tomato data in the appendix, one size group and one condition group was left out. In each case the group dropped was the one including the highest number of observations. In the case of size, this was the group from three

to four inches in diameter. In the case of condition it was the group classed as fairly firm.

This analysis requires some additional interpretation of the regression coefficients for the various size and condition groups. These coefficients for each size and condition group should be interpreted as indicating the increase or decrease in the percentage prices due to an increase of one unit (in this case one per cent) in that group with a corresponding decrease of one unit in the group which was dropped. For example, the coefficient, $b_{17.234 \dots 13} = -.02518$, indicates that each additional one per cent of tomatoes in the group between one and two inches in diameter, *with a corresponding decrease of one per cent in the group between three and four inches in diameter* was associated with a decrease of .02518 in the percentage price. In similar manner an increase of one per cent in the tomatoes classed as firm *with a corresponding decrease of one per cent in the tomatoes classed as fairly firm* was associated with an increase of .43782 in the percentage prices.

The other coefficients of regression can be interpreted in the ordinary manner. They may be converted to terms of dollars and cents to show in money values the average relationship of an increase of one unit of each factor to prices for the whole period studied by multiplying each coefficient divided by 100 by \$1.718, the average market quotation for the period.

There is no reason for assuming that the relationships between each of the factors tabulated and the percentage prices can be approximated by either a straight line or a curve. The day of the week, the place grown and the pack were given code numbers arbitrarily in this tabulation. The factor of pack could be coded with some basis of reason because it is known that layer-packed tomatoes bring the highest prices, face and fill pack coming second, and jumble pack third.

Even in this case, however, there is no reason for supposing that the prices received for tomatoes packed in these three ways tend to vary in a 1, 2, 3 relation. Therefore, the relationship between these three factors and the price percentages may be better expressed as residuals. After adjusting the price percentage to allow for variations in the other factors, these residuals show the percentage prices which were associated with each day of the week, each town of origin, and each pack. These price percentages may be converted to the basis of money value per bushel box in the same way the regression coefficients were converted, and are expressed in this form in the description of results in Part IV.

The coefficients of determination indicate that forty-eight per cent of the squared variation in the percentage prices of this sample of tomatoes can be attributed to the thirteen dependent factors studied. Of this forty-eight per cent, thirty per cent is attributed to the three factors: percentage very soft, percentage soft and percentage firm, which indicate condition. Condition, then, accounts for a large part of the price variation. Growth cracks accounted for seven per cent of the squared variation in percentage prices; pack for five per cent; size (including three factors) for two per cent; color for two per cent; and the other factors each accounted for less than one per cent. It will be noted that condition, growth cracks, and pack together account for forty-two per cent of the squared variation in prices, out of a total of forty-eight per cent accounted for by the thirteen dependent factors. The study, therefore, suggests that local tomato growers have a greater possibility of increasing profits through improved methods of marketing, grading and packing than they can through an attempt to grow any particular sizes, or to obtain a large amount of color.

The coefficient of multiple correlation was .6941, which indicates a fair degree of correlation, but far from a perfect relationship.

The standard error of estimate was 31.9, indicating that, if the regression equation were used to estimate the price percentages of any particular lot of tomatoes, the chances would be 68 out of 100 that the actual price percentage would be within 31.9 per cent above or below the estimate, assuming a normal distribution of prices. The relative accuracy of the mean of the price percentages and the regression equation can be judged from a comparison of the standard deviation of X_1 compared with the standard error of the estimate. This comparison is given below:

$$\begin{array}{rcl} \sigma_1 & = & 44.4 \\ S_{1.23 \dots 13} & = & 31.9 \end{array}$$

It is evident that these thirteen dependent factors come far short of offering a complete explanation of variations in the percentage prices, but that an estimate made on the basis of these thirteen factors is considerably more reliable than the mean of the price percentage.

VARIATION IN DAY-TO-DAY DEMAND FOR TOMATOES

The variation in the demand for tomatoes from day to day during the week was studied by separating out the records for Monday, Tuesday, etc., and making separate analyses of each of the six resulting series to find for each week-day the relationship of prices to the per cent of color, the per cent $\frac{3}{4}$ inches in diameter, and the percent firm.

The variation in the relationship between the percentage prices and these three factors can be judged by comparing the coefficients of regression and determination for each factor on the various week-days.

The coefficients of regression for color indicate that the highest premiums paid for this factor are on Thursday, Tuesday and Friday, while the coefficient of determination indicates that only on Tuesday did this factor account for

more than three per cent in the squared variation in the price percentage.

The highest coefficient of regression for the three to four inch size was on Friday, while Saturday gives a minus coefficient, indicating a preference for other, and evidently smaller sizes on that day. That large sizes are important on Fridays is borne out by the coefficient of determination on that day, which indicates that this factor accounted for twenty-three per cent of the squared variation in the percentage prices.

The highest premiums for firm tomatoes, as shown by the regression coefficients, were paid on Thursdays. Next in order of importance came Saturdays, Tuesdays, Fridays, Mondays and Wednesdays. On Wednesdays the premium for firm tomatoes was less than one third the premium paid on Thursdays. The determination coefficients indicate that seventy-three per cent of the squared variation in prices on Thursdays was accounted for by this factor, while it accounted for forty per cent on Tuesdays, thirty-eight per cent on Saturdays, thirty per cent on Mondays, twenty-nine per cent on Fridays, and only seven per cent on Wednesdays.

It is evident from the preceding discussion that the demand for color, large sizes, and firm tomatoes varies considerably from day to day during the week.

The coefficients of multiple correlation indicate a high degree of relationship between these factors and the percentage prices on Thursdays; a good relationship on Fridays and Saturdays; a fair relationship on Tuesdays and Mondays; and a less significant relationship on Wednesdays.

ANALYSIS OF HOT-HOUSE CUCUMBER PRICES

The forty-nine inspection records of hot-house cucumbers which were made from May 5 to October 16, 1925 included only two quality factors which were in suitable form for

the multiple correlation analysis. These were length and diameter. In tabulating the records, the average diameter of each lot was stated as a percentage of the length in order to express more accurately the shape of the cucumbers. A preliminary analysis of the data suggested that the diameter in inches was not so important a factor in determining prices as was the relationship between the diameter and the length. For example, a diameter of two inches would be almost ideal for a cucumber ten inches long, while it would be much too large in the case of five-inch cucumbers to command high prices.

The prices of the various lots were expressed as percentages of the average daily quotation for good quality cucumbers in the Boston Farmers' Produce Market Report. This was done for the reasons explained in the discussion of the analysis of the prices of asparagus and tomatoes. A tabulation of the data used in the analysis of hot-house cucumber prices will be found on page 142, of the appendix.

The coefficients of regression: $b_{12.3} = +4.937$, and $b_{13.2} = -1.990$ indicate that one additional inch in length was associated with an average increase of 4.937 in the percentage prices, while one additional unit in the percentage diameter was associated with an average decrease of 1.99 in the percentage prices. Converting these coefficients to terms of dollars and cents, by multiplying by \$5.044, the average of the daily market quotations, and dividing by 100 it was found that, at the average level of prices for the period studied, the average relationship between length and prices was an increase of 29.4 cents per inch of length. Each additional unit in the percentage diameter was associated with a decrease of 10.0 cents in prices.

The coefficients of determination: $d_{12.3} = +.112$, and $d_{13.2} = +.221$ indicate that about eleven per cent of the squared variation in the percentage prices is attributed to variation

in length, while about twenty-two per cent is attributed to the relation between diameter and length.

The coefficient of multiple correlation is .577. It is evident from the coefficients of determination and multiple correlation that this analysis fails to explain accurately the variation in the percentage prices in terms of length and diameter. The coefficient $R_{1.23} = .577$ indicates only a fair degree of relationship between the percentage prices and these two factors.

This is substantiated by the standard error $S_{1.23} = 23.67$. When this error is compared with the standard deviation of the percentage prices ($\sigma_1 = 29.23$), it will be seen that, while length and percentage diameter give a better estimate of percentage prices than does the mean of the percentage prices, a large part of the variation in the dependent factor is yet unexplained.

The unexplained portion of the variation in the percentage prices may be attributed to two possible reasons. The first reason is that other factors, not included in the study, may be responsible. The second reason is that the statistical analysis presented above does not show the true relationship between length, diameter and prices. In the above analysis it has been assumed that the relationship between length and percentage prices and that between percentage diameter and percentage prices were both linear; that is, that a unit variation in each dependent factor would be associated with a constant amount of increase or decrease in the percentage prices. This would mean, for example, that, if an additional inch in length was associated with an average increase of twenty-nine cents in prices that this average increase would remain constant throughout the scale from five inches to ten inches, and we would expect the same difference in prices between five-inch and six-inch cucumbers as between nine-inch and ten-inch cucumbers.

In order to test the linearity of these relationships, the residuals of the dependent factor were plotted against length and against percentage diameter, and as this test indicated a decided departure from the straight line, a curvilinear correlation analysis was made.¹ By means of this analysis, the departure of the relationship from the straight line may be estimated by successive approximations. These approximations resulted in the relationship shown in Figure 7 and also on pages 149 and 150 in the appendix.

The curve relationship results in an index of multiple correlation of $P_{1.23}$.764, which is considerably higher than the coefficient of multiple correlation $R_{1.23}$.577. It is evident that the true relationships between length and percentage prices, and percentage diameter and percentage prices are stated more accurately by the curve than by the straight line.²

¹ The methods used in this analysis may be found in the following article: M. J. B. Ezekiel, "A Method of Handling Curvilinear Correlation for any Number of Variables," *Journal of the American Statistical Association*, vol. xix, n. s. no. 148, 1924.

² It is possible that the joint relationship between length, diameter and percentage prices is not accurately expressed by either the straight-line equation or by the curvilinear relationship. The multiple correlation methods in both cases measure the net influence of each independent factor on the dependent factor when all other factors are at their means. Thus, the straight line and the curve which estimate the relationship between percentage prices and length might be considered as accurate only for cucumbers of an average percentage diameter.

The joint relationship between length, diameter, and percentage prices might have been determined by a "regression surface" following the methods suggested by Ezekiel. (See footnote on page 97.) As a check on the methods used here, such a "regression surface" was determined, but failed to increase the accuracy of the estimates or to indicate any important departure from the relationships given above. It was, therefore, concluded that the curve indicating the relationship between length and percentage prices is a fairly accurate statement for all percentage diameters, while the curve indicating the relationship between percentage diameter and percentage prices is a fairly accurate statement for all lengths.

The standard error of the estimate on the basis of the curve relationships is reduced to 22.2. The accuracy of estimates based on the curve relationship can be judged by comparing this standard error with the standard error of the straight-line equation, (23.67), and with the standard deviation of the percentage prices (29.23).

CONCLUSION

This analysis demonstrates that Boston market prices of certain vegetables are determined to a considerable degree by measurable quality factors. While it has been impossible to account for all the variations in prices by corresponding variations in quality factors, it is suggested that the study has yielded results which are useful to the vegetable grower and interesting to the economist. Perfect correlation between quality factors and prices probably never exists in the market place. Such a condition would necessitate absolute equality in bargaining power and ability on the part of all individual buyers and sellers. Except for this fact, however, such studies as the present one are limited only by the ability of the student to find satisfactory measures for the important quality factors.

The present study may suggest further research in this field of prices. The field is large, and, in the opinion of the writer, offers a great opportunity to the statistician and to the economist for original work.

APPENDIX

TABLE I

NATIVE ASPARAGUS—SUMMARY OF ORIGINAL DATA

X_2 <i>Green</i> (hundredths of inches)	X_3 <i>No. of</i> <i>Stalks</i>	X_4 <i>Variation</i> <i>in Size</i>	X_1 <i>Percentage</i> <i>Price</i>
500	11	14	125
500	19	0	100
500	28	17	93
450	20	33	68
450	13	9	90
500	9	11	83
550	13	14	63
500	16	14	63
550	12	14	81
550	18	11	90
550	12	8	98
525	19	20	92
500	32	11	68
450	16	27	60
800	17	8	69
600	12	9	90
500	18	20	82
575	18	9	82
575	11	14	60
900	24	9	150
550	19	20	79
550	12	9	90
950	20	9	120
550	19	20	69
600	15	9	100
550	16	9	100
350	29	20	46
500	30	11	67
500	19	9	93
500	10	17	112
950	19	9	175
525	38	14	75
475	23	14	62
500	12	17	103
500	20	14	93
350	18	20	62
600	15	9	100

TABLE 1—Continued

X_2 <i>Green</i> (hundredths of inches)	X_3 <i>No. of</i> <i>Stalks</i>	X_4 <i>Variation</i> <i>in Size</i>	X_1 <i>Percentage</i> <i>Price</i>
500	22	11	125
625	15	17	100
900	20	25	150
500	11	8	112
350	25	17	43
300	24	11	37
525	19	9	75
525	11	8	91
950	21	20	171
525	36	25	64
400	25	27	50
550	12	8	91
550	20	25	75
700	20	9	100
550	18	9	71
500	12	8	108
525	19	9	85
950	20	8	183
550	11	17	103
650	14	17	126
550	24	33	68
475	18	33	68
350	25	14	53
550	12	14	84
600	45	33	45
575	11	14	97
550	20	17	85
400	16	20	64
950	20	17	152
600	16	20	91
525	40	25	57
525	12	8	92
425	16	20	53
500	20	9	85
500	10	14	96
950	20	9	142
550	35	14	64
550	15	9	75
700	20	27	100
600	12	8	93

TABLE 1—Continued

X_2 Green (hundredths of inches)	X_3 No. of Stalks	X_4 Variation in Size	X_1 Percentage Price
900	20	0	150
450	18	9	75
450	23	18	62
450	12	8	112
450	19	0	93
900	18	9	150
500	35	14	75
800	14	8	112
600	15	9	97
475	12	7	97
425	16	38	87
900	20	11	150
525	12	14	107
525	20	17	93
700	15	27	106
500	24	20	81
400	27	14	68
600	12	14	93
575	19	9	84
650	20	11	103
600	12	17	112
500	12	0	103
900	20	9	137
600	40	33	65
800	19	17	105
450	12	0	97
850	21	9	129
650	14	8	97
550	18	9	87
600	12	8	93
400	20	23	53
700	14	8	100
550	12	8	97
550	19	0	90
525	12	0	90
300	30	25	55
575	10	17	100
575	12	9	83
750	14	9	111
450	35	33	66

TABLE 1—Continued

X_2 Green (hundredths of inches)	X_3 No. of Stalks	X_4 Variation in Size	X_1 Percentage Price
525	11	7	100
500	19	9	87
850	20	9	133
550	12	14	100
700	14	14	100
350	25	14	60
600	25	60	60
700	14	17	105
575	12	14	97
525	20	9	90
700	48	14	75
850	20	20	130
600	12	7	111
600	18	9	83
350	24	14	66
550	18	9	100
550	11	0	108
900	25	20	133
750	16	20	122
350	13	8	55
600	13	23	105
650	12	14	105
350	23	33	42
950	22	20	126
750	22	20	115
625	12	7	121
600	18	8	106
500	19	0	97
600	12	14	106
900	22	9	141
600	23	25	70
850	14	17	121
800	32	17	64
725	25	14	93
900	22	11	129
650	12	12	120
700	19	11	80
600	37	25	56
900	20	11	146
450	12	7	60
575	12	7	82

TABLE 1—Continued

X_2 Green (hundredths of inches)	X_3 No. of Stalks	X_4 Variation in Size	X_1 Percentage Price
350	21	14	39
750	18	20	100
450	24	11	44
400	21	33	44
700	14	8	88
575	21	25	66
650	17	16	120
650	29	44	80
650	12	8	120
550	24	11	60
900	26	25	146
450	12	8	110
575	22	20	85
525	40	14	35
800	19	9	114
600	14	9	107
500	38	14	53
675	20	0	78
900	22	11	114
450	39	14	50
550	12	8	96
800	20	9	114
600	36	14	42
600	14	8	100
600	14	8	78
450	14	33	57
350	28	14	46
450	16	8	78
350	19	42	32
550	45	16	35
700	35	42	57
800	18	20	128
600	18	9	80
750	35	14	48
650	18	27	100
500	19	40	93
400	25	33	52
350	18	25	47
800	21	11	133
400	40	20	33
350	18	11	55
475	12	9	120

TABLE 2

OUT-DOOR TOMATOES—SUMMARY OF ORIGINAL INSPECTION RECORDS

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Variation	% Very Soft	% Soft	% Firm	% Growth Cracks	% per cent
14	4	26	3	60	—	80	—	20	—	—	—	—	—
14	4	2	2	70	—	70	—	30	—	25	—	25	—
14	4	2	2	95	—	80	—	20	—	10	—	5	1
15	5	2	2	90	—	80	—	20	10	90	—	5	1
17	1	2	3	95	—	95	—	5	—	25	—	2	1
17	1	8	4	80	—	40	—	40	—	—	—	—	1
17	1	2	2	98	—	99	—	—	—	—	—	5	1
17	1	6	3	60	—	85	5	30	—	—	25	5	1
18	2	7	4	95	—	80	—	20	—	3	—	1	—
18	2	10	4	90	—	70	10	60	—	—	—	—	1
18	2	4	3	85	—	85	—	15	—	5	—	5	1
18	2	14	2	95	—	50	—	50	—	10	—	2	1
18	2	4	2	90	—	25	—	25	—	—	—	1	1
18	2	6	3	75	—	90	—	10	—	—	80	—	—
19	3	6	2	65	—	60	10	70	—	10	—	—	—
19	3	7	4	65	—	80	10	50	—	—	—	5	1
19	3	4	4	75	—	60	10	70	—	—	25	10	1
19	3	4	3	95	—	50	—	50	—	—	75	2	1
19	3	4	4	80	—	80	—	20	—	—	85	2	1
19	3	4	3	65	—	80	5	35	—	—	—	—	1
19	3	4	4	85	—	80	5	35	—	—	85	2	1
19	3	4	3	85	—	80	5	35	—	—	95	1	1
19	3	3	2	50	99	—	—	—	—	—	—	—	1
20	4	4	3	90	—	70	—	30	—	—	—	—	1
20	4	4	2	60	—	85	5	30	—	—	20	10	1
20	4	4	2	70	80	20	—	20	—	20	—	10	1
20	4	2	4	75	—	15	5	35	—	5	15	—	1
20	4	4	3	80	—	85	—	15	—	—	—	5	1
20	4	4	3	90	—	60	10	70	—	—	—	1	1
20	4	4	4	90	—	15	—	15	—	—	5	—	1
20	4	5	2	85	90	10	—	10	—	—	—	—	1
23	1	11	2	75	30	65	—	50	—	50	—	20	—
23	1	11	4	98	—	80	5	35	—	90	—	10	—
23	1	4	3	60	—	30	10	70	—	20	—	5	—
23	1	4	2	75	—	50	25	125	—	—	10	20	—
23	1	6	3	75	—	10	15	65	—	15	—	2	—
23	1	13	4	95	—	20	10	60	—	—	75	—	—

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁
rend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Vari- ation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per- centage Prices
23	I	II	4	80	—	15	15	65	—	20	—	I	104
23	I	6	3	60	—	60	20	100	—	20	—	—	104
23	I	3	2	70	—	50	25	125	—	—	20	2	104
23	I	4	4	95	20	70	—	60	—	10	—	—	118
23	I	II	4	65	—	85	—	15	—	20	—	2	118
23	I	4	3	95	20	70	—	40	—	20	—	5	118
23	I	5	3	70	—	60	—	40	—	—	—	I	118
23	I	12	3	70	—	20	10	60	—	—	—	I	114
23	I	3	3	85	—	85	—	15	—	—	—	2	118
23	I	4	4	90	—	90	—	10	—	—	—	3	114
23	I	4	3	60	10	70	—	60	—	—	10	2	118
23	I	4	3	60	—	10	10	50	—	—	80	5	134
24	2	4	4	70	—	90	—	10	—	—	—	5	103
24	2	3	4	75	—	10	20	60	—	10	—	5	130
24	2	II	4	55	—	70	—	30	—	20	10	2	115
24	2	4	3	50	30	60	—	70	—	—	—	2	130
24	2	4	4	50	—	65	10	65	—	—	—	I	135
24	2	4	4	70	—	30	20	110	—	—	—	2	135
24	2	4	4	50	—	5	5	25	—	—	50	I	135
24	2	3	3	98	—	50	—	50	—	99	—	I	154
24	2	4	4	65	—	50	10	80	—	—	—	I	154
24	2	4	4	80	—	50	10	80	—	—	10	2	154
24	2	I	14	90	—	10	10	50	—	20	—	2	174
25	3	4	3	90	—	40	10	80	—	10	30	2	104
25	3	3	4	85	—	80	15	35	—	20	—	3	104
25	3	4	3	65	—	40	10	80	—	—	90	2	104
25	3	II	4	80	—	80	—	20	—	90	—	—	125
25	3	4	2	70	—	40	15	105	—	—	70	2	125
25	3	6	3	60	—	50	5	65	—	—	90	2	130
25	3	II	4	65	—	30	10	70	—	—	80	I	141
25	3	14	3	80	—	70	—	30	—	—	90	—	146
26	4	II	4	80	—	15	5	35	—	—	10	I	109
26	4	4	3	90	—	60	10	70	—	10	—	5	57
26	4	4	2	85	—	80	5	35	—	20	—	15	102
26	4	4	4	80	—	30	5	55	—	10	—	I	109
26	4	4	4	65	—	50	—	5	—	10	—	—	109
26	4	4	4	95	—	80	5	35	—	90	—	2	109
26	4	4	4	65	—	5	10	30	—	—	90	—	109

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Variation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per cent Pri-
26	4	4	4	70	—	30	10	70	—	10	—	2	10
26	4	4	4	80	—	5	15	35	—	10	—	2	10
26	4	11	4	60	—	80	5	35	—	—	90	1	10
26	4	6	4	50	—	10	10	50	—	10	—	2	11
26	4	5	4	40	—	80	5	35	—	—	—	1	11
26	4	5	4	60	—	70	10	60	—	—	10	1	11
26	4	5	4	50	—	40	20	120	—	—	80	1	11
26	4	11	4	40	—	10	40	80	—	—	80	2	11
26	4	4	4	95	—	30	30	150	—	—	—	5	11
27	5	5	3	60	—	80	5	35	—	—	70	5	7
27	5	3	4	60	—	—	80	20	—	—	80	10	9
27	5	11	3	60	—	80	—	20	—	10	70	1	10
27	5	4	3	60	—	80	—	20	—	20	—	10	10
27	5	6	4	90	—	75	—	25	—	5	70	2	10
27	5	11	4	50	—	—	80	20	—	—	90	—	11
27	5	14	4	80	—	—	80	20	—	—	10	1	11
27	5	4	3	90	—	80	—	20	—	—	80	1	12
27	5	4	3	80	—	70	—	30	—	—	90	1	12
27	5	5	2	85	—	40	10	80	—	10	—	10	13
27	5	5	4	80	—	70	10	60	—	—	90	5	13
27	5	6	3	90	—	50	5	65	—	—	10	1	13
27	5	11	4	75	—	—	15	15	—	—	10	1	13
27	5	5	4	75	—	5	20	40	—	—	20	5	13
27	5	5	3	90	—	50	10	80	—	—	10	—	15
27	5	6	2	44	—	20	15	80	—	—	99	1	17
31	3	11	3	70	—	10	10	50	—	80	—	5	10
31	3	6	2	90	—	20	—	20	20	15	—	1	12
31	3	4	2	90	—	90	2	16	—	50	—	2	12
31	3	11	3	60	—	80	—	20	—	—	90	2	12
31	3	15	4	60	—	20	—	20	—	—	90	2	12
31	3	11	3	60	—	20	10	60	—	10	—	10	13
31	3	15	4	90	—	20	5	40	—	—	—	10	13
31	3	4	3	95	—	20	—	20	—	10	—	—	14
31	3	12	4	80	—	—	2	20	—	99	—	2	15
31	3	6	2	75	—	—	15	15	—	—	90	3	16
31	3	3	4	35	—	90	—	10	—	—	85	—	16
31	3	11	3	85	—	—	25	25	—	—	80	5	17
31	3	12	2	95	—	10	10	50	—	—	—	2	18

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Vari- ation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per- centage Prices
37	3	2	4	85	—	80	5	35	—	10	10	1	104
37	3	3	3	85	—	50	5	55	20	25	—	1	104
37	3	4	3	60	—	30	20	110	—	75	—	1	104
37	3	6	3	65	—	30	20	110	—	80	—	2	104
37	3	11	3	50	—	40	20	120	—	90	—	1	104
37	3	2	4	75	—	20	20	100	—	—	10	1	104
37	3	5	3	90	—	15	10	55	—	20	5	5	125
37	3	5	3	90	—	30	30	150	—	30	—	10	125
37	3	3	3	85	—	15	25	85	—	—	10	1	125
37	3	11	4	75	—	20	30	110	—	10	10	2	145
37	3	2	4	75	—	—	30	30	—	—	20	—	146
37	3	3	4	95	—	20	10	60	—	50	—	1	150
37	3	4	3	95	—	75	—	25	—	25	—	2	160
37	3	4	4	60	—	40	30	150	—	80	—	1	161
37	3	4	3	90	—	99	—	—	—	10	—	10	202
38	4	4	3	95	—	85	—	15	—	25	—	1	63
38	4	3	3	85	—	75	—	25	—	10	20	1	67
38	4	11	4	95	—	75	—	25	—	90	—	1	67
38	4	4	3	85	—	75	5	40	—	10	—	1	70
38	4	4	4	80	—	15	—	15	—	—	20	—	76
38	4	3	3	98	—	15	15	75	—	95	—	5	89
38	4	4	3	95	—	60	—	40	—	99	—	1	89
38	4	2	4	85	—	—	5	5	—	—	25	1	89
38	4	3	4	60	—	75	5	40	—	10	10	—	112
38	4	3	2	50	—	5	25	45	—	—	25	2	112
38	4	3	3	60	—	—	20	20	—	—	80	5	112
38	4	11	3	65	—	10	10	50	—	25	50	1	134
38	4	3	4	50	—	5	20	40	—	—	25	1	134
38	4	3	3	80	—	30	5	50	—	10	10	1	156
38	4	2	4	75	—	5	20	40	—	—	25	—	223
40	6	2	3	90	—	40	—	40	—	99	—	1	42
40	6	3	3	90	—	15	—	15	—	10	—	1	42
40	6	4	3	98	40	60	—	40	—	99	—	10	54
40	6	3	3	70	—	30	10	70	—	80	—	—	63
40	6	3	4	50	—	—	40	40	—	99	—	2	63
40	6	4	4	95	—	—	30	30	—	99	—	2	63
40	6	2	4	90	10	90	—	10	—	—	—	5	167
40	6	4	3	60	10	80	—	50	—	—	20	1	80

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Variation	% Very Soft	% Soft	% Firm	% Growth Cracks	Percentage Price
40	6	3	3	80	—	20	—	20	—	80	—	25	83
40	6	11	3	95	—	10	30	70	—	90	—	5	83
40	6	2	4	60	—	10	5	20	—	10	20	—	104
40	6	3	3	95	—	20	5	40	—	99	—	2	83
40	6	6	3	50	—	20	10	60	—	10	—	5	89
40	6	3	3	80	—	40	10	80	—	60	—	2	89
40	6	6	3	90	—	20	20	100	—	—	—	2	89
40	6	3	2	95	—	10	10	50	—	90	—	2	112
40	6	6	2	90	—	—	30	30	—	99	—	1	112
40	6	3	4	70	—	20	10	60	—	—	10	—	112
43	3	2	3	75	30	70	—	30	—	99	—	—	50
43	3	6	2	80	—	90	—	10	—	99	—	1	57
43	3	16	2	90	10	80	—	50	—	99	—	1	56
43	3	17	3	60	10	85	—	30	—	90	—	—	63
43	3	11	3	90	30	60	—	70	—	99	—	1	63
43	3	4	2	97	20	80	—	20	—	99	—	5	71
43	3	4	3	80	10	90	—	10	—	10	—	1	83
43	3	3	3	75	—	30	—	30	—	10	—	3	83
43	3	3	4	75	10	80	—	50	—	90	—	1	83
43	3	2	4	80	—	30	—	30	—	99	—	4	83
43	3	7	4	85	—	15	5	35	—	—	2	—	94
43	3	7	3	90	—	80	—	20	—	—	10	—	94
43	3	3	4	85	—	20	10	60	—	10	—	—	104
44	4	2	3	50	30	70	—	30	—	10	—	—	41
44	4	2	2	80	—	70	—	30	—	99	—	5	53
44	4	16	3	60	10	70	—	60	—	—	—	1	44
44	4	8	4	75	—	99	—	—	—	—	99	—	179
44	4	7	4	60	—	—	—	—	—	—	99	—	241
44	4	2	4	50	20	75	—	40	—	99	—	—	78
45	5	19	3	60	—	90	—	10	—	10	—	10	52
45	5	20	2	75	—	50	—	50	—	75	—	10	41
45	5	4	3	90	—	—	10	10	20	80	—	1	64
45	5	15	4	95	—	10	15	65	—	90	—	5	86
45	5	7	4	75	—	90	—	10	—	15	—	1	89
45	5	22	4	75	—	99	—	—	—	90	—	3	96
45	5	16	4	50	—	20	—	20	—	10	—	1	107
45	5	6	4	65	—	30	—	30	—	10	—	—	125
45	5	21	4	90	—	—	—	—	—	10	—	—	143

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Vari- ation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per- centage Prices
46	6	3	3	95	—	99	—	—	—	—	—	1	107
47	1	16	4	65	—	40	—	40	—	99	—	60	33
47	1	23	2	85	30	40	—	150	—	99	—	25	36
47	1	19	4	50	—	99	—	—	—	—	—	10	54
47	1	2	3	80	20	60	—	100	—	99	—	35	71
47	1	2	4	70	—	60	—	40	—	20	—	40	83
47	1	13	3	90	—	75	—	25	—	50	—	15	83
47	1	2	4	95	—	40	—	40	—	20	—	1	165
47	1	3	3	60	—	—	—	—	—	—	10	—	167
48	2	24	2	90	—	30	—	30	—	20	—	80	23
48	2	2	2	80	—	—	50	50	80	20	—	50	27
48	2	19	3	85	—	20	—	20	—	99	—	30	47
48	2	7	4	80	—	50	—	50	—	50	—	2	83
48	2	12	3	60	—	25	—	25	—	—	90	10	100
48	2	18	3	75	—	—	25	25	—	—	90	1	167
48	2	7	4	85	—	30	—	30	—	—	99	—	230
49	3	11	2	80	—	20	30	110	—	20	—	60	44
49	3	19	3	75	—	65	—	35	—	—	—	45	50
49	3	25	2	90	—	65	—	35	10	90	—	50	23
49	3	26	2	85	—	33	33	165	—	10	—	5	83
49	3	17	3	95	—	25	—	25	—	99	—	3	109
49	3	2	3	90	—	30	—	30	—	—	99	5	110
49	3	13	4	75	—	20	—	20	—	20	—	5	130
49	3	7	4	80	—	99	—	—	—	—	80	5	217
49	3	7	4	90	—	—	16	15	—	—	90	2	304
50	4	7	2	90	—	5	—	35	10	90	—	50	35
50	4	11	2	80	30	60	—	70	—	99	—	60	50
50	4	26	2	85	—	60	—	40	—	90	—	5	125
50	4	2	30	90	—	30	—	30	—	20	20	5	150
50	4	16	4	75	—	20	—	20	—	20	—	2	150
50	4	3	4	80	—	99	—	—	—	—	80	25	250
50	4	7	4	95	—	—	15	15	—	—	99	3	350
51	5	24	2	90	—	75	—	25	99	—	—	35	35
51	5	4	3	95	40	60	—	40	—	99	—	30	60
51	5	27	3	80	—	30	—	30	30	70	—	40	75
51	5	16	3	90	—	50	—	50	—	95	—	35	85
51	5	17	3	95	—	25	—	25	—	99	—	3	125
51	5	2	3	85	—	15	—	15	—	—	—	20	125

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Variation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per-centag Price
51	5	18	3	90	—	10	—	10	—	20	—	5	165
51	5	4	4	90	—	—	—	—	—	—	90	5	265
52	6	16	3	50	10	45	—	85	—	90	20	80	32
52	6	24	3	50	—	25	—	25	—	—	90	30	63
52	6	19	3	75	—	25	—	25	—	75	—	50	65
52	6	18	4	75	10	40	—	80	—	—	—	60	142
52	6	6	3	95	40	60	—	40	—	—	90	—	184
53	1	28	3	50	40	60	—	40	25	75	—	80	56
53	1	29	3	85	25	50	—	125	—	60	—	40	65
53	1	23	4	95	—	70	—	30	—	—	—	2	68
53	1	2	2	75	—	50	—	50	—	65	—	40	83
53	1	15	4	85	10	65	—	65	—	—	25	40	95
53	1	19	4	70	—	30	—	30	—	90	—	50	105
53	1	28	2	90	30	60	—	70	—	99	—	1	105
53	1	28	2	50	20	50	—	110	—	—	50	2	105
53	1	15	3	80	—	60	—	40	—	—	10	10	132
53	1	7	3	80	—	40	—	40	—	—	99	5	222
54	2	23	3	60	—	60	—	40	50	50	—	5	56
54	2	15	3	70	—	35	—	35	—	99	—	5	57
54	2	7	2	70	—	50	—	50	—	40	—	2	85
54	2	16	4	75	—	60	—	40	—	75	—	75	85
54	2	4	3	40	—	—	—	—	—	—	60	80	97
54	2	30	2	95	—	20	20	100	—	—	75	2	142
54	2	7	4	80	—	50	—	50	—	—	99	—	199
55	3	7	3	50	—	20	20	100	—	—	25	20	139
55	3	15	3	95	15	85	—	15	—	90	—	20	56
55	3	19	3	75	—	75	—	25	—	75	—	10	85
55	3	23	3	90	—	50	—	50	—	90	—	20	94
55	3	15	2	60	60	20	—	100	—	99	—	5	111
55	3	12	2	90	—	33	33	165	—	—	15	5	114
55	3	19	3	90	40	60	—	40	—	10	—	2	167
56	4	12	2	85	33	34	—	165	—	85	—	20	56
56	4	2	2	99	—	99	—	—	—	80	—	20	94
56	4	15	2	60	60	40	—	40	—	—	60	5	111
56	4	7	3	85	—	20	20	100	—	—	25	20	139
56	4	31	4	85	—	50	—	50	—	—	99	85	250
57	5	19	3	70	—	60	—	40	—	99	—	70	56
57	5	24	3	75	—	50	—	50	—	15	10	80	70

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Vari- ation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per- centage Prices
57	5	19	4	50	—	99	—	—	—	—	90	10	83
57	5	3	3	90	—	50	—	50	—	10	—	25	100
57	5	16	3	85	—	40	—	40	—	60	—	25	100
57	5	2	3	90	—	30	—	30	—	—	90	5	139
57	5	21	4	95	—	99	—	—	—	—	99	—	149
58	6	16	3	95	—	60	—	40	—	99	—	60	59
58	6	2	3	95	—	—	—	—	—	75	—	40	88
59	1	23	2	90	—	—	15	15	15	85	—	10	60
59	1	19	3	75	—	25	50	125	—	99	—	20	76
59	1	2	3	95	—	—	15	15	15	85	—	10	88
59	1	19	3	65	—	40	20	120	—	15	10	50	101
59	1	16	3	85	—	—	25	25	—	60	—	2	107
59	1	18	3	75	—	—	10	10	—	—	99	2	149
59	1	7	4	80	—	25	25	125	—	—	99	—	179
60	2	15	2	50	99	—	—	—	—	70	—	—	61
60	2	19	4	50	—	90	—	10	—	—	—	—	89
60	2	32	2	85	—	25	50	125	—	—	65	10	101
60	2	12	3	75	—	—	20	20	—	—	90	2	149
60	2	7	4	90	—	75	—	25	—	—	50	—	183
61	3	19	3	85	—	75	—	25	99	—	—	20	61
61	3	16	2	80	—	60	—	40	—	—	—	10	91
61	3	15	3	70	—	25	—	25	—	—	80	1	122
61	3	21	4	60	—	60	—	40	—	—	70	10	147
61	3	28	4	90	—	90	—	10	—	—	10	10	159
61	3	12	4	90	—	—	15	15	—	—	99	2	183
62	4	7	3	75	—	25	5	45	—	80	—	10	59
62	4	2	3	85	—	60	—	40	—	60	10	50	79
62	4	34	2	90	80	20	—	20	—	40	30	10	88
62	4	2	3	80	—	90	—	10	—	10	60	10	118
62	4	7	4	60	—	—	25	25	—	—	99	2	142
62	4	35	3	75	—	40	—	40	—	5	25	50	147
63	5	32	3	80	—	60	—	40	—	20	20	40	63
63	5	21	3	90	—	99	—	—	—	60	—	40	63
63	5	19	2	60	10	70	—	60	40	45	—	—	79
63	5	7	4	90	—	—	—	—	—	—	99	10	184
63	5	19	3	90	5	85	—	30	—	10	—	50	79
63	5	16	3	95	—	80	—	20	—	90	—	80	95
63	5	34	4	90	80	20	—	20	—	—	—	—	132

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Variation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per-centage Prices
64	6	21	3	85	—	30	—	30	—	90	—	35	62
64	6	2	3	95	—	60	20	100	—	90	—	50	71
65	1	19	3	85	20	60	—	100	—	80	—	50	71
65	1	19	2	65	—	60	—	40	—	—	—	40	90
65	1	3	4	75	—	80	—	20	—	—	25	50	100
65	1	16	3	50	—	60	—	40	—	—	90	10	119
65	1	27	4	85	—	60	—	40	—	—	95	30	130
65	1	7	4	90	—	—	—	—	—	—	99	2	167
66	2	2	3	90	—	—	20	20	—	99	—	—	109
66	2	16	3	65	10	80	20	50	—	—	80	20	109
66	2	16	3	85	20	60	—	100	—	—	—	10	130
66	2	7	4	90	—	60	—	40	—	—	95	—	218
67	3	2	3	85	10	80	—	50	—	10	—	2	92
67	3	38	2	80	—	80	—	20	—	20	40	1	92
67	3	19	3	80	—	75	—	25	—	20	40	15	104
67	3	22	4	80	—	80	—	20	—	20	20	—	139
67	3	31	4	90	—	99	—	—	—	—	99	—	208
68	4	16	3	80	60	40	—	40	—	35	—	25	104
68	4	15	3	80	—	80	—	20	—	—	95	30	104
68	4	22	4	90	—	99	—	—	—	20	—	10	115
68	4	16	4	90	—	—	—	—	—	—	75	10	154
68	4	3	3	80	—	99	—	—	—	10	10	5	157
68	4	7	4	75	35	65	—	35	—	—	80	—	217
69	5	37	3	90	—	99	—	—	—	99	—	—	82
69	5	3	3	80	10	75	—	55	—	—	50	10	115
69	5	19	3	90	—	50	—	40	—	10	20	50	117
69	5	2	3	70	—	50	—	40	—	—	30	25	117
69	5	16	3	90	90	10	—	10	—	—	50	—	135
69	5	11	4	90	—	—	—	—	—	—	90	—	200
71	1	21	3	10	20	80	—	20	—	75	—	15	100
71	1	16	3	90	—	99	—	—	—	20	—	25	107
71	1	27	4	60	—	—	—	—	—	—	99	10	120
71	1	16	3	90	25	75	—	25	—	—	50	10	131
71	1	7	4	85	—	99	—	—	—	—	90	—	233
73	3	2	3	65	—	99	—	—	—	—	60	1	67
73	3	21	3	90	—	99	—	—	—	—	90	10	148
73	3	7	4	85	—	99	—	—	—	—	80	5	195
74	4	39	4	85	—	60	—	40	—	15	35	5	111

TABLE 2—Continued

X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁
Trend	Day of Week	Place Grown	Pack	% Color	% 1"-2"	% 2"-3"	% 4"-5"	Index of Vari- ation	% Very Soft	% Soft	% Firm	% Growth Cracks	Per- centage Prices
74	4	22	3	85	—	99	—	—	—	—	75	5	133
74	4	7	4	90	—	99	—	—	—	—	75	5	182
74	4	40	3	80	—	80	—	20	—	10	15	5	67
75	5	22	4	85	—	99	—	—	—	—	85	5	130
75	5	39	4	85	—	—	—	—	—	—	99	—	173
77	1	16	4	90	75	20	—	40	—	—	15	10	74
77	1	2	4	75	—	80	—	—	—	—	90	10	92
77	1	22	4	85	—	20	—	20	—	—	80	50	92
77	1	7	4	85	—	85	—	15	—	—	85	10	148
78	2	48	4	70	—	99	—	—	—	20	—	—	58
78	2	16	3	50	—	99	—	—	—	20	70	50	67
78	2	16	2	90	—	75	—	25	—	—	30	1	100
79	3	22	4	80	—	—	—	—	—	—	98	40	92
79	3	16	4	85	—	40	—	40	—	—	90	35	95
80	4	3	2	90	—	60	—	40	—	38	12	50	18
80	4	3	3	50	20	40	—	120	—	25	—	50	26
80	4	7	4	80	—	60	—	40	—	—	75	10	46
80	4	22	4	75	—	80	—	20	—	—	99	2	124
81	5	3	3	90	30	50	—	110	—	20	—	50	65
81	5	22	4	75	—	40	—	40	—	—	80	35	100
81	5	43	4	80	—	99	—	—	—	—	80	10	105
83	1	22	3	80	60	30	—	70	—	—	40	50	62
83	1	16	2	60	—	99	—	—	—	99	—	40	67
84	2	10	3	85	—	80	—	20	—	—	95	5	175
85	3	45	3	80	40	60	—	40	—	40	20	50	42
85	3	22	3	80	—	75	—	25	—	20	40	40	66
85	3	10	3	80	—	80	—	20	—	—	95	5	175
85	3	2	3	80	—	99	—	—	—	—	90	30	133
86	4	10	3	80	—	80	—	20	—	—	95	5	175

TABLE 3
HOT-HOUSE CUCUMBERS—SUMMARY OF ORIGINAL DATA

X_2 Length (inches)	X_3 Percentage Diameter	X_1 Percentage Price
7.0	32	100
9.5	26	118
10.0	24	134
6.0	31	52
7.5	37	136
6.5	35	52
6.0	38	120
10.5	20	116
8.0	28	113
7.5	30	109
8.9	25	118
9.5	26	118
8.5	29	116
8.0	30	108
7.5	28	63
8.5	29	108
9.5	33	39
8.5	28	122
8.5	25	122
8.0	28	131
6.0	37	44
7.0	27	138
8.8	25	125
8.8	26	138
8.5	26	132
6.0	40	44
9.0	28	125
9.0	17	125
5.5	45	37
9.5	16	122
5.5	39	37
10.0	20	125
7.5	30	91
9.0	25	102
8.0	40	108
7.0	30	63
9.0	25	94
7.0	30	70

TABLE 3—Continued

X_2 Length (inches)	X_3 Percentage Diameter	X_1 Percentage Price
7.0	34	110
8.5	28	78
9.5	24	120
9.5	29	103
6.8	28	105
6.5	27	99
6.5	35	125
8.0	28	109
8.5	22	104
9.0	25	119
9.5	30	97

TABLE 4

FACTORS INFLUENCING PRICES OF NATIVE ASPARAGUS

(In this summary all prices are on the basis of one dozen standard bunches weighing from 1 to 1¼ lbs.)

Period covered by study—May 6 to July 2, 1927

Number of inspection records—200

Average of top market quotation	\$2.782
Average price in percentage of quotation	90.095
Average length of green color	5.8875 inches
Average number of stalks per bunch	19.555
Average coefficient of quartile dispersion in size of stalks	14.875

Product Moments

	X ₁		X ₂		X ₃		X ₄
	Price				Number of		
	Percentage		Green		Stalks		Variation
X ₁	+ 1,063.64	+	3,430.89	—	100.92	—	82.35
X ₂			+ 24,317.19	—	17.01	—	154.54
X ₃				+	61.33	+	25.51
X ₄						+	83.07

Coefficients of Regression

Green	b _{12.34}	+	.13826
No. of Stalks	b _{13.24}	—	1.53394
Variation	b _{14.23}	—	.27553

Coefficients of Determination

Green	d _{12.34}	+	.40837
No. of Stalks	d _{13.24}	+	.14554
Variation	d _{14.23}	+	.02133
Total	d _{12.34}		.57524

Coefficient of Multiple Correlation	R _{1.234}	.75838
Standard Error of Estimate	S _{1.234}	21.253
Coefficient of Multiple Correlation corrected for number of observations and for number of independent factors	R _{1.234}	.737

Effect of Factors in Dollars and Cents

Each additional inch of green adds	.3845 cents
Each additional stalk per bunch decreases prices	4.6 cents
Each additional percent variation in size decreases prices	.765 cents

TABLE 5

FACTORS INFLUENCING PRICES OF OUT DOOR TOMATOES

(All prices per Massachusetts Standard Box—approximately one bushel)

Period covered by the study—May 19 to November 10, 1926

Number of inspection records—370

Average of average daily market quotations	\$1.718
Average price in percentage of quotation	111.24
Average trend (days numbered consecutively)	45.57
Average day of week (Mon. 1; Tues. 2, etc.)	3.30
Average town where produced (arbitrarily designated)	10.68
Average pack (Jumble 2, Face & Fill 3, Layer 4)	3.22
Average percentage color	78.23
Average percentage from 1 to 2 inches in diameter	5.22
Average percentage from 2 to 3 inches in diameter	48.14
Average percentage from 4 to 5 inches in diameter	5.94
Average index of variation	40.44
Average percentage very soft	1.35
Average percentage soft	25.65
Average percentage firm	26.68
Average percentage of growth cracks	11.67

TABLE 5—Continued
COEFFICIENTS OF REGRESSION AND DETERMINATION

<i>Coefficient of Regression</i>			
	<i>Original</i>	<i>Converted to basis of cents</i>	<i>Coefficient of Determination</i>
Trend	—0.3703	—06 cents	+0.00059
Day of Week	—2.45792	—4.22 "	+0.00645
Place Grown	—29004	—50 "	+0.00734
Pack	+9.13307	+15.69 "	+0.05067
% Color	+63228	+1.09 "	+0.01884
% 1"-2"	—02518	—04 "	+0.00101
% 2"-3"	—19791	—34 "	+0.01948
% 4"-5"	—00046	—0.0008 "	.00000
Variation	—04630	—08 "	+0.00547
% V. Soft	—44466	—76 "	+0.01780
% Soft	—24718	—42 "	+0.09076
% Firm	+43782	+75 "	+0.19089
% Growth Cracks .	—52413	—90 "	+0.07251
Coefficient of Multiple Correlation	$R_{1.23\dots 13}$		.6941
Coefficient of Multiple Determination	$D_{1.23\dots 13}$		.4818
Standard Error of Estimate	$S_{1.23\dots 13}$		31.9
Coefficient of Multiple Correlation corrected for number of observations and for number of independent factors	$R_{1.23\dots 13}$		.680

Residuals of X_1 , associated with X_3 , X_4 and X_5

X ₃ (Day of Week)	X ₄ (Place Grown)	X ₅ (Pack)
1. Monday 112.91	7. Winchester 137.14	2. Jumble 103.09
2. Tuesday ... 113.55	5. Somerset .. 118.83	3. Face & Fill . 108.53
3. Wednesday . 114.28	4. Dighton .. 115.51	4. Layer 119.43
4. Thursday .. 112.10	3. Arlington . 114.32	
5. Friday 101.70	11. Burlington. 114.04	
6. Saturday ... 95.88	6. Belmont .. 113.95	
	19. Stow 110.92	
	16. Newton ... 107.64	
	2. Woburn ... 103.72	
	22. Scituate ... 94.15	

TABLE 6

FACTORS INFLUENCING TOMATO PRICES ON VARIOUS WEEK DAYS

(All prices per Mass. Standard Box—approximately one bushel)

Average of various factors for each week day

	X_1	X_2	X_3	X_4
	Price	%	%	%
	Percentage	Color	3"-4"	Firm
Monday	107.2	77.9	36.1	23.3
Tuesday	116.3	75.4	43.0	28.1
Wednesday	117.1	79.4	37.7	29.3
Thursday	115.3	76.5	37.9	28.1
Friday	110.3	80.2	40.7	31.9
Saturday	82.2	80.6	54.2	8.9

Product Moments

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
σ_1^2	1429	2131	1781	2808	1636	954
p_{12}	55	153	71	29	70	86
p_{18}	234	181	244	293	625	-127
p_{14}	766	934	399	1089	803	291
σ_2^2	172	241	134	216	180	276
p_{23}	-37	51	-1	-32	44	-85
p_{24}	-21	-8	-21	-140	-107	-84
σ_3^2	866	745	814	925	1037	826
p_{34}	318	136	66	137	8	208
σ_4^2	1381	1465	1483	1319	1542	544

Coefficients of Regression

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
% Color $b_{12.34}$	+.405	+.638	+.573	+.738	+.607	+.440
% 3"-4" $b_{13.24}$	+.090	+.085	+.230	+.212	+.574	-.288
% Firm $b_{14.23}$	+.540	+.633	+.264	+.883	+.562	+.713

Coefficients of Determination

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
% Color $d_{12.34}$	.016	.067	.027	.016	.028	.070
% 3"-4" $d_{13.24}$	.015	.010	.046	.047	.233	.067
% Firm $d_{14.23}$	.300	.404	.071	.729	.293	.381

Coefficients of Multiple Correlation

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
$R_{1.234}$	.575	.693	.380	.890	.744	.720

TABLE 7

FACTORS INFLUENCING PRICES OF HOT HOUSE CUCUMBERS
(Prices are per Massachusetts Standard Box—approximately on bushel)

Period covered by study May 5 to Oct. 16, 1925

Number of inspection records 49

1. Straight Line Correlation

Average of top market quotations	\$5.044
Average percentage price	102.0
Average length (inches)	8.0
Average diameter (ratio to length) ..	.29

Product Moments

	X_1 Price Percentage	X_2 Length	X_3 Diam. Ratio
X_1	854.5	19.4	-94.8
X_2		1.7	-5.6
X_3			33.9

Coefficients of Regression

	Original Figures	Converted to Basis of Cents
$b_{12.3}$ Length	+4.937	+29.4 cents
$b_{13.2}$ Diameter Ratio ...	-1.990	-10.0 "

Coefficients of Determination

$d_{12.3}$ Length	.112
$d_{13.2}$ Diameter Ratio	.221
$R_{1.23}$ Coefficient of Multiple Correlation	.577
$S_{1.23}$ Standard Error of Estimate	23.67

2. Curvilinear Correlation

Length (inches)	Price Percentage
5.5	57
6.0	82
6.5	94
7.0	102
7.5	106.5
8.0	109
8.5	110.7
9.0	111.3
9.5	112
10.0	112
10.5	112

TABLE 7—Continued

Diameter Ratio	Price	Percentage
.16		107
.20		111
.24		112.5
.28		103
.32		88
.36		82
.40		82
Index of Multiple Correlation	P _{1.23}	.764
Standard Error of Estimate	S _{1.23}	22.2
Index of Multiple Correlation corrected for number of observations and for number of independent factors	P _{1.23}	.752

TABLE 8

SAMPLE INSPECTION RECORD FOR ASPARAGUS

Date — May 6, 1927 Address of Shipper — Eastham, Massachusetts

Inches of green color 5.0

No. of stalks per bunch 11

Percentage of stalks of following diameters (measured at butts)

.2	.5	.8	20
.3	.6	30	.9
.4	.7	40	1.0

(.8 — .6) 2

Quartile Coefficient of Dispersion $\frac{\quad}{.7} = 14$

Crooked Stalks 0

Frayed Stalks 0

Price per dozen bunches \$5.00

Top quotation 4.00

Percentage price 125

Comments (none)

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